

Proceeding of the National Symposium
On

Problems of Land Degradation in Egypt and Africa: Causes, Environment Hazards and Conservation Methods

23-24 March 2002

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Land Degradation Problems and Their Environmental and Economic Impacts[1]

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INTRODUCTION

Soil is a vital nonrenewable natural resource essential to civilization which provides us with the basic human needs, i.e., food, fiber and shelter. In many parts of the world, particularly in Africa, the soil has been degraded by misuse and mismanagement resulting in potentially irreversible losses in its productivity. These finding emphasize the critical importance of protecting soil against all forms of degradation. A strong need, therefore, arose to develop appropriate indicators of soil quality in relation to specific soil function. Land degradation – induced changes in soil quality are related to crop growth and yield and have a direct environmental as well as productivity and economic impact. Conserving soils from all form of land degradation or soil quality determine agricultural sustainability, environmental quality and as a consequence of both plant, animal and human health.

Land degradation – a man made problem:

Most forms of land degradation are man-made problems. Although there are some physical environmental factors evolved, but misuse and mismanagement are important factors. The food gap due to increasing population puts more pressure on the use of the land resulting in serious forms of land degradation which considered as irreversible process with the severe and continued misuse and poor management.

How land degrades?

This is an important question. Its answer makes us solve the problems of land degradation. As we know land is the only source for the majority of the basic material that man needs (food, fiber and shelter). Each piece of land has its own capacity for producing a certain amount of yield. This capacity

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[1] Keynote presented at: National Symposium on " Problems of land degradation in Egypt and Africa: causes, environmental hazards and conservation methods", 23 – 24 March 2002, Inst. of African Research & Studies. Cairo University.

depends on the internal capacity of the land and the inputs usually added by man such as water, work, capital seeds, fertilizer . . etc.

When the inputs are at the optimum rate with regard to the potential capacity of the land, we can expect a certain amount of production. This amount could be increased to a certain limit by increasing one or more of the inputs. This, however will continue only for a short time until the balance between the soil and its forming factors is upset. This situation will lead to the use of more and more inputs to keep the land at desired level of production until the time will come when the land is no longer productive no matter how much inputs you add. Land degradation, therefore means less production with the same level of inputs, or the some production with more inputs, or ultimately, less production with more inputs.

Over-cultivation, mechanization, overgrazing, over-irrigation are practices lead to the exhaustion of the land and cause land degradation through loosening soil surfaces, removing vegetal cover, compactness, water logging, surface runoff and salinization – various aspects of modernization and economic and demographic expansion have brought changes which have increased population pressure on the land and disrupted the balance between production and land conservation.

Analysis of the land degradation indicates that the most significant factor involved is the misuse of the limited potential of the land in the fragile ecosystems such as desert and marginal lands where the process of desertification occurs.

Land degradation and economic development:

Land degradation problems in Africa are serious and far reaching to the extent that the process of development could be halted and the whole economy actually retarded by the occurrence of such problems. Because of their magnitudes in terms of the large areas of land affected (relative to the very limited cultivated land in Egypt for example) and in terms of the millions of people who suffer the consequences, land degradation problems in Egypt and Africa constitute an imminent danger to African agriculture especially in the case of resources scarcity needed for development.

Growth of population is critical in Egypt because of the relatively small cultivatable land. Land/man ratio has currently decreased to less than 0.1 feddan/man which is indeed danger and threatens food security. Despite the efforts which have been made toward industrialization, agriculture still the backbone of economy in Egypt and many African countries where it is the

source of livelihood of more than half of the population. Agriculture's contribution to GDP is still high (25 % in Egypt). Agriculture also is main source of foreign exchange needed to finance the economic development.

The intensification of agriculture with poor management accelerates the rate of land degradation. Food supply situation will be worse in the future if the current trends of land degradation did not change drastically.

What makes the problem of land degradation worth attention is that reclamation and development of new land is costly and not always successful. So, it is very important to give priority for investments to the conservation of the old productive land against all forms of degradation.

The world map of desertification showed that the majority of Egyptian lands are actual desert and located in the arid to hyper-arid zone. The risk of desertification is high where most areas of Egypt are subject to sand movement, soil salinization and alkalinization and also subject to human pressure. There are other factors make the situation worse in Egypt:

1. Egypt is largely agricultural and the Egyptian economy depends very much on land where the agricultural sector contributes to about 25% of the Gross Domestic Product (GDP).
2. The pressure of increasing population combined with the scarcity of the cultivated areas force people to ask more from the land than it can give.
3. The absence of Nile alluvium after the High Dam made the soil loss its fertility and reduces its ability to defend against desert attack.
4. The damage may be irreversible with the severe and continued misuse and poor management particularly in the marginal lands which form an interference zone between desert and alluvial sediments with a limited capacity.
5. Most of the Egyptian farmers are small and poor and are not able to follow any effective conservation measures.
6. Egyptian agriculture is very intensive and almost totally dependent on irrigation. This leads to many forms of serious land degradation.

Problems of land degradation:

I. Soil salinity:

The spread of salt – affected soils as a result of

1. Perennial irrigation.
2. Reuse of drain water or underground water.
3. neglecting the establishment of artificial drainage system.

It's the most serious form of land degradation in Egypt with respect to the size of the problem, its rate of increase and its effect on the agricultural production. An average of 25% production losses due to salinity problems. The only solution of this problem is the creation of good drainage system.

II. Soil fertility:

Another form of land degradation is the deterioration of soil fertility. In spite of the favorable development in fertilizer use, there are some evidences that extensive areas of our soils are incapable of supplying plants with sufficient amounts of many nutrients. Factors responsible for the deterioration of soil fertility in Egypt are well known. Among these factors are:

- The removal of great amount of nutrients from the soil, especially with the very extensive agriculture, without a systematic replacement.
- The absence of Nile alluvium after the completion of Aswan High Dam. This Nile alluvium was a good and continuous source for nutrients, especially potassium and micronutrients.
- The expansion of agriculture in the new lands which are mainly sandy and/or calcareous with poor and limited capacity for nutrients supply.

A reduction of at least 10% in Egyptian soil agricultural production is due to the deterioration of soil fertility. To overcome the problem of soil fertility, there are some constraints should be removed:

- The lack of efficient laboratories for soil and plant analysis to assess soil fertility and fertilizers requirements for various crops in different types of soils.
- The role of extension service is limited.
- The use of farmyard manure and other natural fertilizer materials (organic bio-fertilizers) is still limited.

Fertility problems in tropical Africa associated with soil acidity. Poor crop growth in acid soils is directly correlated with aluminum saturation rather than pH per se. Acid soil infertility is due to one or more of the following factors: Al toxicity, Ca or Mg deficiency and Mn toxicity. Concentration of soil solution aluminum above 1 ppm often causes Al toxicity and direct yield reduction. Al-toxicity injury to root system and may produce or accentuate Ca and P deficiencies. When Al precipitates by liming and Ca level rises, root growth progress normally.

III. Encroachment of desert:

The desert sediments that are continually added to the fertile cultivated soils of the Nile valley and delta either by torrents, winds or gravity is a problem needs to be considered and evaluated. Several studies referred to the destructive effects of these desert sediments on the fringes of Nile valley and delta in the interference zones of desert and alluvial sediments. The soils of the interference zones affected by desert attack have generally the following properties (compared to the alluvial soils of the valley close to the Nile stream): light colors, coarse texture, very low content of organic matter, high content of total carbonates, different mineralogical composition and low content of nutrients. These properties of the soils of the interference zones could be used as criteria to identify the area subjected to desert attack. The properties of the desert sediments are pound to cause many harmful effects to the fertile soil and reduce its production capacity. Desert encroachment increased after the construction of Aswan High Dam and loss of the Nile alluvium which was the only natural defense against the desert attack. The Harmful effects of desert sediments have extended over a distance of at least 5 km in both sides of the Nile valley through the fertile cultivated alluvial soils. This is a crucial problem.

At the present, remote sensing techniques are useful tools to give accurate information about the actual size of this problem, its spatial distribution, the rate of its harmful effects in terms of economic losses.

To evaluate the problem economically, let us assume that the affected areas extend over a distance of 5 km on both sides of the Nile valley. The length of the valley is 1200 km. So, the affected area is 5×2 (both sides) $\times 1200 = 12000\ km^2 = 2.857$ million feddan. Let us assume that the reduction in the agricultural production due to the problem is in the order of 25%. This means that the losses due to desert attack amounts to about 8% of the Gross Domestic Product (GDP)

given by Egyptian agriculture. In terms of money it will be in the order of 400 million Egyptian pounds (LE.) yearly. If the present trends did not change, the harmful effects of desert attack may cover the total area of the Nile valley in the near future, especially when we take into consideration the fact that the valley is a very narrow strip of land.

IV. Soil pollution:

Soil pollution is another cause of land degradation. There are several sources for soil pollution differs in their importance from one place to another. Soil pollution should be assessed in terms of their sources, magnitude and effects on agricultural production and human health.

The sources of soil pollution are the following: organic wastes, infectious organisms, industrial inorganic wastes, pesticides, radioactive materials, heavy metals, fertilizers and detergents. Many of these land degrading materials are human inputs. The main source for soil pollution in Egypt is the heavy use of pesticides. The main problem with pesticides remains their degree of persistence in soil and their adsorption on soil particles and reaches to streams to enter into the food chain. Chlorinated hydrocarbons are of major concern in this respect due to their slow decomposition in soil environment. Great care has to be given when selecting the pesticides to be used.

Technology should develop pesticides without adverse effects. Recent ways for pest control depend on the biological control. This trend should be given higher priority in modern agriculture.

V. Non agriculture use:

Non agriculture use of the land is a serious problem in Egypt due to the fact that the agricultural land is very limited and the majority of the people are concentrated on a limited area of the Nile valley and Delta. The size of the problem appears when we know that the area of land reclaimed is little compared with land lost. Assuming even the same, the land lost in non agricultural use is fully productive and the area added did not produce much. The reclaimed areas constitute about 16% of the total cultivated area but produce about 2% only of the total agricultural production. Some investigators used remote sensing techniques to monitor and follow up the problem.

Although there are some rules and regulations against building on the agricultural land or removing the top soil for brick-making, the rules

and regulations are not effective and the alternative are not available or feasible to the required extent.

VI. Soil erosion:

Soil erosion is another form of land degradation. It affects crop production, constructions, water pollution and loss of plant nutrients. Soil erosion is the removal of top soil either by water or by wind. Although soil erosion by water is a major concern all over the world, this problem is not a serious one in Egypt due to the arid conditions. On the other hand, wind erosion can be a serious problem in some areas. However, it has not been studied in details in Egypt to allow reliable information about the factors involved and the best ways for control.

Economic losses due to soil erosion is estimated by an average of $ 0.5 ton of soil lost. Soil erosion costs U.S. farmers more than $ 1.2 billion per year. Generally, land degradation problems in Egypt and Africa differ from one place to another and from one country to another. Total losses due to land degradation in order of the production were estimated as 2.35 million feddans : 600000 f. losses due to water logging, salinity and alkalinity, 600000 f. due to the deterioration of soil fertility, 350000 f. as affected by desert encroachment and 800000 f. are lost as non agricultural use of the land.

Challenges of Sustainable Land / Water Management in Drylands: NW Coast, EGYPT.[2]

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INTRODUCTION

Land degradation is a central challenge to sustainable development in dry lands. Sustainable development has been defined as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainable development requires due consideration of specific environmental, socio-cultural and economic conditions found in a particular location. Dry Lands are particularly challenged because of their two-fold curse: socioeconomic poverty and environmental degradation of the resource base.

Sustainable Land Management is the Key

It is now widely recognized that agricultural growth, food security, and poverty alleviation are closely linked, but that their achievement over the long term depends on sustainable management of the environment.

The challenge is to put in place management systems, which ensure sustainability, in the face of the wide variations in both temporal and spatial dimensions.

Sustainable land management (SLM) has been defined as "a system of technologies and/or planning that aims to integrate ecological with socioeconomic and political principles in the management of land for agricultural and other purposes to achieve intra- and intergenerational equity". SLM is thus composed of the three development components:
* Technology: appropriate, * Policy: national, regional and
* Land use planning: land assessment and evaluation.

If land management with geo-information is to assist in improving the sustainable use of natural resources, it must have four major orientations: it must be

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[2] Keynote Presented at: National Symposium on Problems of Land Degradation in Egypt and Africa: Causes, Environment Hazards and Conservation Methods (23-24 March 2002), Institute of African Research & Studies, Cairo University.

* Target-oriented, * Client-oriented, * Process-oriented and
* Transdisciplinary.

The Environmental Context of Dry Lands

- Temporal and spatial climatic variability results in temporal and spatial variability in natural resource productivity and use.
- Livestock are assets and are mobile rather than stationary. System sustainability depends on recognizing their role in livelihood strategies.
- Producers land resources involve various forms of common property and fragmented cultivated plots rather than neatly defined contiguous farms.
- Land will have multiple functions, e.g. cropland, grazing and fuel wood production and these functions will change with seasonal and annual climatic conditions.
- Unlike sedentary systems, land use in pastoral systems is large scale. Land used by members of a community often involves multiple watersheds, frequently non-contiguous. Thus areas for planning must comprise more than just an area defined on biophysical grounds. They must comprise the functional areas employed by specific groups of inhabitants in the operation of their production systems.

The Human Response to the Environmental Context in Dry Lands

In semi-arid non-equilibrial ecosystems, where rainfall is low and uncertain, the traditional coping strategy for farmers and herders is to try to maximize production under the rainfall conditions of a given year. Production systems in such areas are also characterized by coping strategies involving:

Flexibility / Diversity
* Variety of crop/ livestock activities
* Movement for cropping
* Movement of livestock for grazing
* Selection of crop for rainfall conditions of the current year.

Water Harvesting
* "Run-on" cultivation using surface run-off
* Cultivation of depressions
* Check-Dams - slow run-off in Seasonal Stream Beds
* Enhance infiltration and soil water storage

Adapted crop species
* Drought / salinity tolerance

These strategies and their mobility component allow for the effective maintenance of stocking rates far in excess of the "carrying capacity" of a fixed land base production system

Understanding of Production Systems in Dry Lands

- Significant work has been undertaken to determine the physical nature and extent of degradation and desertification. Variety of techniques and measurements were proposed for the physical control of environmental degradation at various levels.

- Actions programs to combat degradation are now to originate at the local level and based on understanding of production systems. Local communities have a greater stake than anyone else in managing and improving their agricultural production system while ensuring the long-term ecological balance of their fragile lands.

LEARNING'S FROM NAGHAMISH, NW COAST, EGYPT.

Biophysical Context

* The NW Coastal zone of Egypt extends over 550 km from west of Alexandria to the Libyan border
* Population is about 120,000 Bedouin whose livelihood depends upon largely upon agriculture.
* Bedouin moved into the region from what is now eastern Libya in the 17th century.
* Low and sporadic rainfall (60 year average at Mersa Matrouh 150 mm, CV 45%), clearly within the realm of semi-arid non-equilibrial ecosystem conditions.
* The study area is representative of the conditions on the NW coast in east of Matrouh city.

Goals and Purposes:

The overall goal of this study is to examine the biophysical and socioeconomic dynamics of the Wadi Naghamish area of the NW-Coast of Egypt.

The components of the study are:

1- Understanding Production Systems

2- Evaluating Water and Soil Constraints
3- Soil and Landform Evaluation
4- Land use dynamics
5- Interrelationships between Water, Soils and Land Use
6- Linking Biophysical Constraints with Indigenous Knowledge
7- Geographic Information Systems (GIS) as an integration tool.

Methodology

The research involves:
- Integrating land evaluation and watershed planning and management,
- Farming systems analysis
- Indigenous knowledge and NRM.

Techniques include both classical and participatory approach, along with GIS/RS/Modeling for analysis and integration.

Results and Recommendations

A- Water Management

- The design and storage capacity of each cistern needs to be re-examined.
- Building more but smaller systems reducing the risks of failures.
- There is some additional capacity to extend the construction of check dams. These should be simple indigenous system

B- Soil Management

- Erosion control is important during the rainy season and can be improved with a more extensive check dam network and effective vegetation.
- Integrated soil fertility management is needed

C- Vegetation and Biomass Production

- Avoid expansion of wheat into the dryland farming system
- There is some capacity for drip or trickle irrigation from additional storage capacity of cisterns
- Stocking densities and frequency of grazing should be carefully controlled to avoid loss in species diversity
- The introduction of drought resistant hedgerows using nitrogen fixing trees and shrub is a potential solution worth investigating

D- Production Systems

- The core element of present Bedouin production systems is the small ruminant/cereal/ rangeland production system.

- The focus of research for the improvement of farming systems should concentrate on activities to reduce the "feed gaps" within the system
- Some potential exists for new varieties of rainfed barley with improved grain and/or straw production.
- This research will more likely focus on the potential role of fodder shrubs, atriplex spp. and spineless cactus

What Needs to be Done to Move Towards Sustainable Land Management?

1) Political Commitment
2) Community Participation in the Development Process
3) Rights to Land and Water Use
4) Organisational and Service Efficiency
5) Drought Management and Food Security:
6) Provision of an Adequate Research Base
7) Environmental Monitoring Considerations
8) A Multi-Level Stakeholder Approach to Sustainable Land Management.

Impact of Soil Degradation on Land Productivity of North Nile Delta.

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ABSTRACT

Soil Degradation is defined as a process, which lowers (quantitatively or qualitatively) the current and or the potential capability of soil to produce goods or services. Soil degradation implies a regression from a higher to a lower state; a deterioration in soil productivity and land capability(Mashali 1991).

The north Nile Delta region includes three main landscapes namely; coastal plain, alluvial plain and the interference zone. This area is considered as unstable ecosystem due to the active degradation resulting from the climate, relief, soil properties and processes of unproper farming system. The most active land degradation features are; wind and water erosions, waterlooging, slanization and compaction. These land degradation processes have a negative impacte on land productivity.

Evaluation of land productivity of the area under consideration, showed that eight soil characteristics were considered as limiting factors in land productivity. These factors are i.e., wetness (H), drainage (D), Effective depth (P), Texture / structure (T), Soluble salt concentration (S), Organic matter content (O), cations exchange capacity / nature of clay (A) and Mineral reserve (M). According to the obtained data, the soils of the studied area were grouped into four land productivity classes manely,i.e. II, III, IV and V.

Key Words : land degradation , land productivity, Nile Delta.

INTRODUCTION

The economy of Egypt is suffering from over population problem on a limited arable area Therefore, the agricultural security depends largely on two schemes, which are raising the productivity of the existing cultivable land, and increasing the cultivated area on the desert area. The increase of land productivity can be achieved by application of proper management and controlling of land degradation.

Said (1981) described the early Pliocene and Late Pleistocene deposits, which form the area between Damietta branch and Kalabshu-Zayan areas as follows: The Early Pliocene sediments in the northern Nile Delta environment are thick sand- shale deposits, which carry a rich open marine fauna. It is shallow on top of the late Miocene or older sediments with a marked unconformity, which can be traced on all seismic records with remarkable ease. The sediments include more sand members in their lower part (the Abu Mady formation) and formed of shales in their upper part. This shale section forms the lower part of Kafr El- Shiekh formation. The late Pleistocene is represented by the deposits of the neonile which broke into Egypt sometime in the earlier part of this age and also by the deposits which accumulated during the recessional phases

of this river. Through its history the neonile in this massif has been continuously lowering its course at a rate of 1m / 1000 years. Fluviatile deposits, medium to fine quartz sand alternating with thin layers of micaceous salt .Cross section extends between Damietta branch are elaborated by Saied (1981) which include many geological formations such as Sabkhas, Sand dunes ,neonile sediments, and water bodies.

According to FAO Staff (1966), only two main landscapes were distinguished in North Nile Delta, namely; The Fluvio marine deposits, and the coastal barrier plain and beaches. Both of them are originated from Fluvio and deltaic origin. Between those two landscapes, there is a wide transitional small strip soils (sand over clay and clay over sand.). The Fluvio- marine deposits from the natural extension of the delta's clay top set beds, because they are low lying and consequently badly drained, they are very saline and, therefore not yet, cultivated. The soils of the coastal barrier plain and beaches are predominantly sandy and the topography is basically flat, accepted for the coastal dunes. These sand dunes are rather low and are scattered over the coastal plain west of El-Borg, but attain a height of 15-25 m between El- Borg and the Gharbia drain. Between the plain and Ras El- Bar, vast areas of medium and low sand dunes are found. A manmade but striking feature were reported and the ancient dwelling mound or " tells, which dominate the horizon of the endless flats. Cross section including the geomorphological units passing throughout the investigated area are elaborated according to FAO (1966) as follows: fluvio- marine plains, coastal plain, beaches, swamps, high dunes, medium high and low sand dunes and clay dunes.

The current investigation aims to study selected sites in north Nile Delta by means of aerial photo interpretation and conducting field and laboratory studies on representative soil profiles. Then, applying a mathematical model to evaluate the different land degradation process , which have impact on land productivity.

MATERIAL AND METHODS

1-Location of the sudied area .

The studied area is shown on the topographic maps , N H 36 N1(c,& d), scale 1:50,000 . It is located between Longitudes 31°. 28.13' and 31°. 52' E, and the Latitudes 31°. 18.9' and 31°. 32.29' N bounded to the north by the Mediterranean Sea, to the south by El- Dakahlia Governorate, to the east by Damietta Nile branch and to the west by Kalabshu-Zayan area map (1).

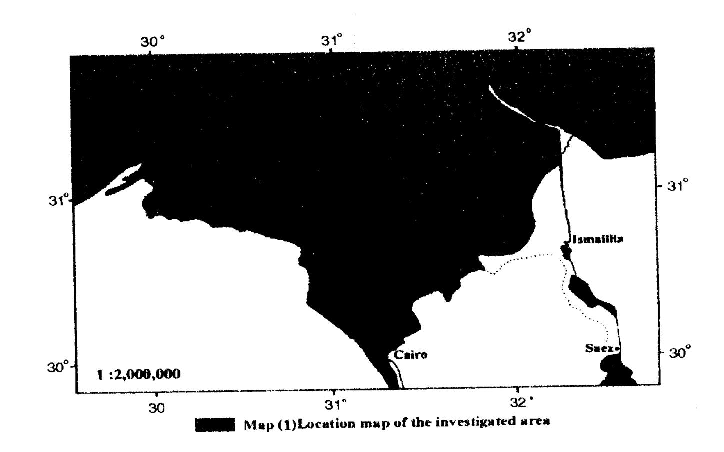
2-Aerial photographs.

Panchromatic aerial-photographs (scale1:40,000) average consisting of 45 photographs (6 runs) have been used for the present study. These available photographs have been taken during the year 1992

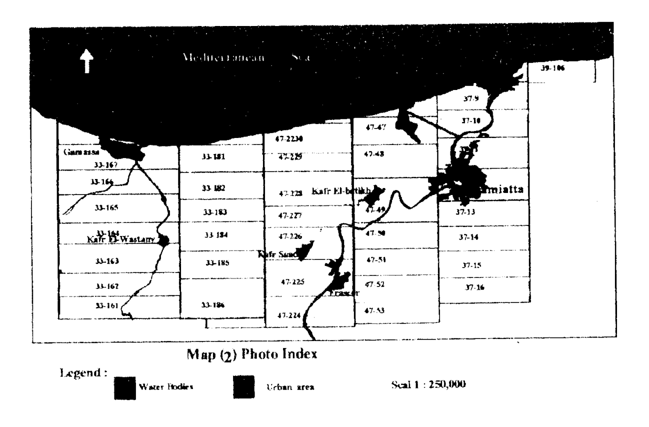
and the technical details of the photographs are given in the following table (1) and map (2)

Table (1): Technical data for the used photographs.

Type of photograph.	Panchromatic.
Format size (cm).	23 x23.
Kind of paper.	Contact.
Flying height.	6128 m.
Focal length (mm).	153.29.
Scale of photo	± 40,000.
Overlap forward.	65 %.
- Overlap lateral.	15 %.



Map (1)Location map of the investigated area



Map (2) Photo Index

2.1 Aerial photo - interpretation.

A loose mosaic was laid out using the alternate photographs. Major landforms were identified by physiographic analysis (Bennema & Gelens 1969) followed by a representative stereo- pairs of photographs that were studied stereoscopically in order to formulate a tentative physiographic legend. Then for interpretation of Aeiral photographs all the photographs were studied stereoscopically and further divisions made using " the physiographic analysis" after Goosen (1967) and Zinck and Valenzuela (1990). Main elements used are, slope, relief, graytone, parceling and natural vegetation.

2. Re-interpretation of photographs.

Detailed photographic analyseis was made in accordance with the field observations, and boundaries between the different units were demarcated .The legend was finalized and the physiographic units were finally translated in terms of soils. A relationship between physiographic units and soil was then worked out.

3-Site selection and soil characterıztaion.

Based on the distribution of physiographic units, four sample areas were selected through the studied area and 27 soil profiles were chosen to represented the studied sample areas as shown in map (2).

Detailed morphological description and classification of the selected soil profiles were recorded on the basis outlined by FAO (1990) and Soil Survey Staff (1999). The collected disturbed samples were air – dried; ground gently, then sieved through 2 mm sieve.The soil samples were mechanically analyzed according to the international method Rowell

(1995) using NH_4 OH as a dispersing agent.-Soil color in both wet and dry samples were determined with the aid of Munssel color charts, Soil Survey staff (1951).The soil chemical analysis was carried out according to Rowell (1995).

RESULTS AND DISCUSSIONS:

Photo-interpretation and Physiography. -

Based on the aerial photo-interpretation and field check the following legend had been formulated with the percentage of each mapping units and total area. The obtained data reveal that, the marine deposits form about 25.7 % of the investigated area, while the fluvio-marine deposits form about 9.9 %, fluvial deposits form about 55.54 %, and water bodies form about 3.5 %.

The soil classification based on the soil taxonomy system (1999) of the American Soil Survey Staff, is applied up to the subgreat group for mapping units. while to family level for the profile description.

The main physiographic units and soil taxonomy of the main mapping units of the investigated areas are given in table (2) and the final soil map, map (4) are reduced to scale 1: 50,000 .

Soil degradation processes:

In the northern part of the Nile Delta, there are many land degradation processes which can be described and discussed as follows;.

Sea water intrusion: This process is noticed along coastline of the Nile Delta mostly due to current action of the Mediterranean Sea. Within nine years (1972- 1982) almost 1500 m has been lost in Rosetta area and Rosetta promenty to the west and Damietta to the east In both cases the eroded materials are deposited east wards. About 1000 m were lost in the period between years (1981- 1988) in the same site. In Damietta promontorry the loss of land of the same peried (1972- 1981) ranged between 125 and 875 m (sadek et al. 1993). Plate No. (1) show water erosion along the shoreline.

Wind Erosion: This process occurs in the coastal plain. Wind erosion has a negative impact on plant growth by the sand –blasting of young crop plants, exposing plant roots, or covering plants with sand. Sand – baslting of plant destroys the leaves and stems or shreds the plant leaves to such an extent that they cannot grow normally.

Wind erosion is much more costly than on field damage. Suspended light clay particles cause air pollution; heavy sand particles moving close to the ground pile up along fence lines, on highways (international coastal road) and around buildings. Plate 2,3 showed the sand dunes encroachment in the road and deposition around building. The studied

area affected by two types of wind erosion namely; sand dunes encroachment and ribbles.

Salinization: The accumulation of excess salts in the root zone resulting in partial or complete loss of soil productivity. The reason of salinization may be due to one or more of the following reasons; Sea water intrusion, inadequate drainage and insufficient leaching of irrigation water, Salt levels my become high enough to reduce crop growth. This process is observed in the coastal plain and interference zone.

Waterlogging: Waterlogging is responsible for the salinity problem. Over irringation causes rising of groundwater tables. This process occurs when internal drainage is impeded. Evaporation of the groundwater accumulates salts on the soil surface and decreases crop yields. In some cases, high water tables alone can cause aeration problems and reduce crop yields even in the absence of high salt levels. The depth of groundwater table in the investigated area range between (50- 80 cm). We noted this process in the coastal plain and interference zone.

Compaction and Crusting: These processes are occurred mainly in the alluvial plain due to the heavy texture. It increased significantly in some farm where heavy machinery is used or due to low content of organic matter. Raindrops (Splash), heavy machinery and puddling the soils by livestock are the main contributors to crust and Plow pan formation.

Land productivity:

Land productivity is assessed using the productivity model after Riquier et al.(1970) .The system suggests the calculation of the productivity index considering eight factors to determine soil productivity, viz.: wetness (H), Drainage (D), Effective depth (P), Texture / structure (T), Soluble salt concentration(S), Organic matter content (O), cation exchange capacity / nature of clay (A) and Mineral reserve (M) . An attempt has been made to introduce a mathematical formula expressing productivity as a resultant of the various factors, considered the following formula :

Productivity Index (PI) = H x D x P x T x S x O x A x M

Each factor is considered on scale from 0 to 100. The actual percentages being multiplied by each other. The resultant index of productivity, also ranging between 0 and 100, is set against a scale placing the soil productivity in one out of five productivity classes.

The goal of the current study is classifying of land productivity to different categories, each of which corresponding to a certain level of

detail. At each level the interpretation differs in precision, objectives, requirements and assumptions. These successive steps help users in a better understanding of the system.

Land productivity classification shows that, the groups are distinguished in precise numerical units. Classifications, which meet soil productivity requirements, would be taken as the heighest grades. Soils with extreme limitations would be the lowest ones. Intermediate grades would be placed in between the two extreme conditions. Soil characteristics relevant to productivity are shown in Table (3), while assessment of soil productivity could be obtained by matching soil characteristics with its counterpart of the Riquier' s model rating as shown in Table (4).

Productivity rating, soil characteristics, land productivity index* and grades** are shown in table (4) and the decision tree of Riquier et al.(1970) in table (5) :-

Land productivity of the coastal plain:

All the mapping units which represent the coastal plain (C111, C121, C122, C123, C131, C133 and C213) have been classified as grade V(PI ranging between 2.4 –19.5 , the precentage of these units are 17.43% (15819.86 fedden). The main limiting factors in this landscape are, moisture content, effective depth, drainage conditions, texture/ structure, organic matter content and salinity.

On the mapping unit C132 (man made terraces) has been classified as grade IV due to proper management such as increasing soil depth by addition of sand and organic matter. Irrigation with fresh water (mixed water of drain & canal) improve the soil characteristics. The total area is 9.8% (8851.22 fedden)from the study aree.

Land productivity assessment of the fluvio-marine plain:

The mapping units in this landscape could be grouped in three productivity grades as follows; mapping units C311, C312 and C313 which have the productivity grade II .These units 7.87% (7094.78 Fedden) respactevelly of the study area. The unit C321 has grade III which represent 1.23% (1111.46 Fedden) , while C322. has grade IV which covers arround 9.8% (1309 fedden) .

The main limiting factors in this landscape are texture/ structure, effective depth and drainage conditions.

Land productivity assessment of the alluvial plain:

All mapping units of the alluvial plain (A1, A2, A3, A4, A5 and A6) have been evaluated as grade II and these units have 58.48% (52647.98 Fedden) of the study area respectivily.

The application of proper management, which has been observed clearly during the field investigation, considered one of the main reasons for increasing soil productivity. The obtained results are in agreement

with the previous study of (El-Toukhy 1995). There are limited number of constraints in the alluvial plain represented by heavy textured soils and compacted structure.

Table (3): Soil characteristics of the investigated area.

Mapping unit	H (Moisture)	D (Drainage)	P (Effective depth)	T (Texture/ structure)	S (Soluble salt concentration)	O (Organic matter content)	A Mineral exchange capacity / nature of clay	M (Mineral reserve)
C111	H2c	D3b	P4	T2a	S2	O1	A0	M2a
C121	H2c	D4	P6	T2a	S1	O1	A1	M2a
C122	H2c	D3b	P4	T2a	S1	O1	A1	M2a
C123	H2c	D3a	P3	T2a	S1	O1	A0	M2a
C131	H2c	D3a	P3	T2a	S2	O2	A1	M2a
C132	H2c	D4	P5	T2a	S1	O1	A1	M2a
C133	H2c	D3a	P3	T2a	S2	O1	A1	M2a
C213	H2c	D4	P6	T2a	S1	O1	Ao	M2a
C311	H2c	D4	P6	T4b	S2	O3	A2	M3a
C312	H2c	D4	P6	T6a	S1	O3	A1	M3a
C313	H2c	D3b	P4	T7	S1	O2	A2	M3a
C321	H2c	D3a	P4	T4b	S1	O2	A1	M3a
C322	H2c	D3a	P3	T4a	S1	O2	A1	M3a
A1	H2c	D4	P6	T5b	S1	O3	A2	M2C
A2	H2c	D4	P6	T5b	S1	O3	A2	M2C
A3	H2c	D4	P6	T5b	S1	O3	A2	M2C
A4	H2c	D4	P6	T5b	S1	O3	A2	M2C
A5	H2c	D4	P6	T5b	S1	O3	A2	M2C
A6	H2c	D4	P6	T5b	S1	O2	A2	M2C

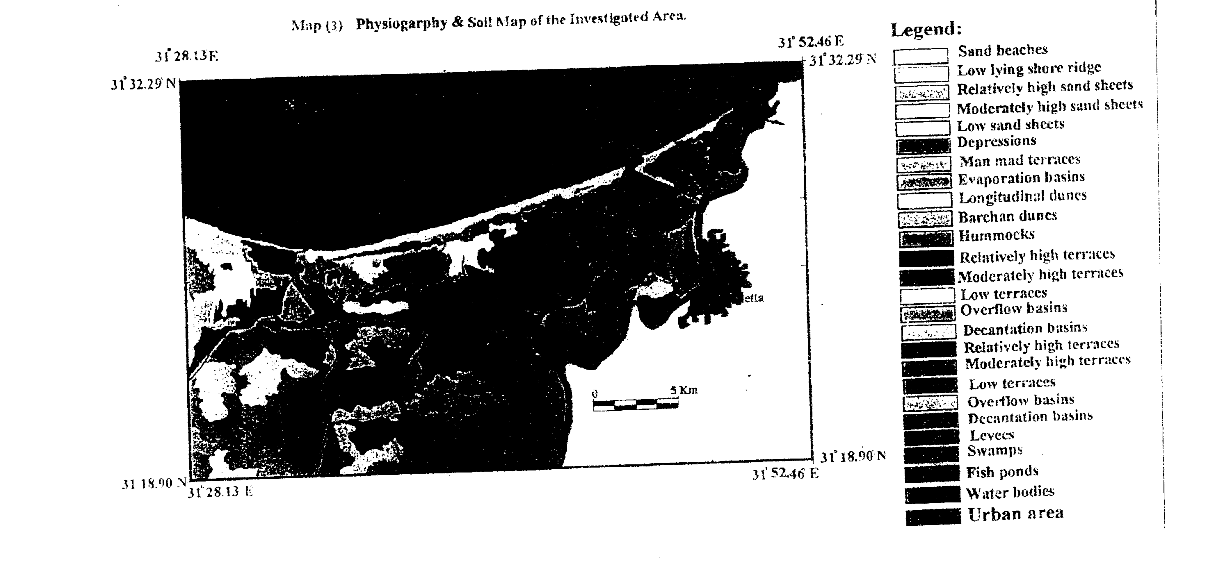
Appreviation According to Riquier et al.(1970) .

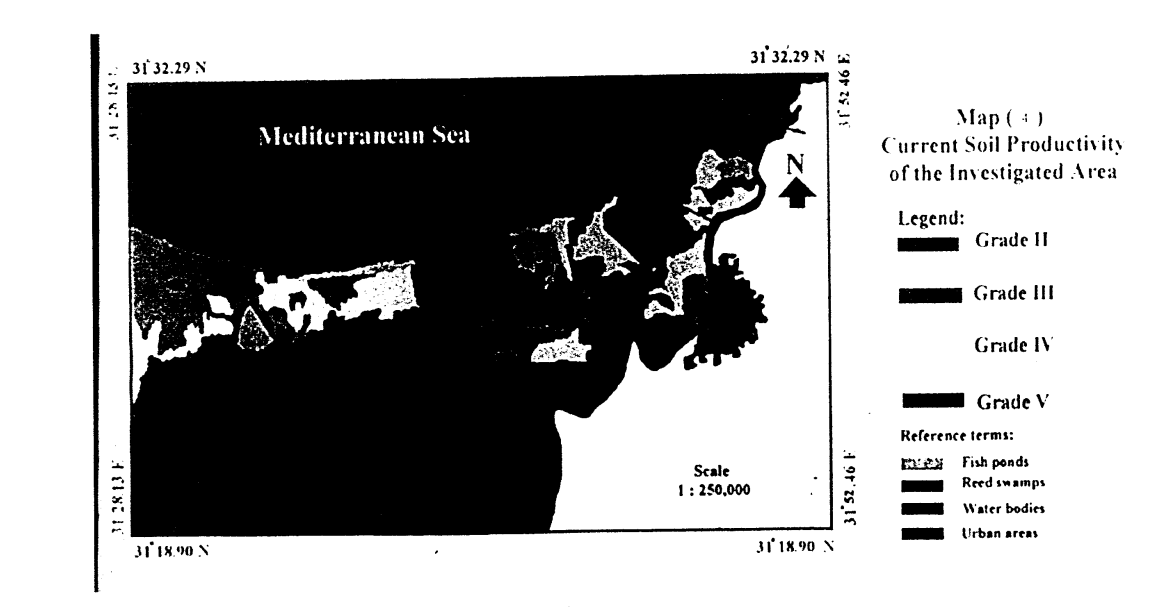
Table (4) : Assessment of soil productivity of the investigated area

Mapping unit	H	D	P	T	S	O	A	M	P.I*	G**
C111	40	90	80	10	70	85	85	85	1.2	V
C121	40	100	100	10	100	85	90	85	2.6	V
C122	40	90	80	10	100	85	85	85	1.7	V
C123	40	80	50	10	100	85	90	85	1.04	V
C131	40	80	50	30	100	90	90	85	3.3	V
C132	100	100	100	30	100	85	90	85	19.5	IV
C133	40	80	50	10	70	85	90	85	0.7	V
C213	40	100	100	10	100	85	85	85	2.4	V
C311	100	100	100	60	70	100	95	90	35.91	II
C312	100	100	100	60	100	100	90	90	48.6	II
C313	100	90	80	100	100	90	95	90	55.4	II
C321	100	80	80	60	100	90	90	90	27.9	III
C322	100	80	50	30	100	90	90	90	8.7	IV
A1	100	100	100	60	90	100	95	95	48.7	II
A2	100	100	100	60	100	100	95	95	54.1	II
A3	100	100	100	60	100	100	95	95	54.1	II
A4	100	100	100	60	100	100	95	95	54.1	II
A5	100	100	100	60	100	90	95	95	48.7	II
A6	100	100	100	60	100	100	95	95	54.1	II

Rating values were estimated and the methodolgy introdced by Riquier et al.(1970)

Map (3) **Physiogarphy & Soil Map of the Investigated Area.**




Map (4)
Current Soil Productivity
of the Investigated Area
Legend:
Grade II
Grade III
Grade IV
Grade V
Reference terms:
Fish ponds
Reed swamps
Water bodies
Urban areas
Mediterranean Sea
N
Scale
1 : 250,000
31°32.29 N
31°32.29 N
31°18.90 N
31°18.90 N
31°52.46 E
31°52.46 E

The data in table (4) shows that productivity of the studid soils is low in th coastal area and increases inland. The soils of the coastal plain have the lowest productivity grad V, whil the man made terraces are considerted grade IV. Soils of the fluvio-marine and alluvial plain are the most prodcutivit soils as they blong to grade II while the decantation basin in the fluvio-marine are grad IV.

Productivity index allover the studied area illustrated in map (4).

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تأثير تدهور التربة على إنتاجية الاراضى شمال الدلتا .

فؤاد حنا سليمان[1] ، شوقى د أحمد صادق[1] ، سامى إبراهيم عبد الرحمن[2]، عبد العزيز بلال عبد المنطلب بلال[2]
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٢ - الهيئة القومية للإستشعار عن بعد و علوم الفضاء

يهدف هذا البحث إلى دراسة عمليات تدهور الأراضى بإستخدام تكنولوجيا الإستشعار عن بعد لإنتاج خرائط التر بة و إنتاجية الأراضى حيث تم استخدام الصور الجوية لسنة ١٩٩٢ بمقياس رسم ١:٤٠٠٠٠.

تعرف عمليات تهور الأراضى على أنها العمليات التى تؤدى إلى النقص فى القدرة الإنتاجية للأرض سواء كانت الحالية أو المستقبلية من حيث الكم و النوع و كذلك الخدمات و تدهور الأراضى يؤدى إلى تراجع صفات التربة من الرتب العليا إلى الرتب الدنيا فى إنتاجية و قدرة الأراضى.
تشمل منطقة الدراسة على ثلاث و حدات فيزيوجرافية و هى السهل الساحلى و السهل الفيضى و منطقة التداخل فيما بينهما و تعتبر المنطقة ذات نظام بيئ غير ثابت بسسب عمليات تدهور الأراضى النشطة الناشئة عن المناخ و الطبوغرافية و صفات التربة و العمليات الزراعية و حيث وجد أن العمليات النشطة لتدهور الأرضى هى النحر بالرياح و المياه ، تغدق الأراضى ؛ الملوحة و القلوية و تضاغط التربة و هذه العمليات تأثر على إنتاجية الأراضى.

و لقد دلت نتائج تقييم إنتاجية الأراضى لمنطقه الدراسة على أن العوامل التى تحد من من الإنتاجية هى الأبتلال و حالة الصرف و العمق الفعال و قوام وبناء التربة و نوع الطين و السعة التبادلية للتربة و المخزون المعدنى فى الأرض و قسمت منطقة الدراسة بناء على تلك العوامل إلى الرتب التالية و هى الرتبة الثانية وتشمل٥٩٧٤٢,٧٦ فدان و٣٥, ٦٦ % والثالة وتشمل ٤٦و١١١١ فدان و ٢٣و٥١% و الرابعة وتشمل١٠١٦٠,٢٢ فدان و ٥١١,٢٤% و الخامسة وتشمل ١٧,٤٣ % و ١٥٨١٩,٨٦ فدان من المساحة المدروسة أما باقى المساحة فهى عبارة عن الأجسام المائية و المزارع السماكية و المستنقعات و تشمل و ٣٣٢٧,٢٤ فدان و٣,٧٥ %.

Desertification in Egypt

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ABSTRACT

The major challenge facing Egypt now is the better and management of very limited resources. While, the dangerous problem facing the cultivated and under reclaimed lands is the desertification. Lands under reclamation reach to about 8 million feddans restricted around the Nile Valley and the Nile Delta. While, the under reclaimed lands reach to about 3.5 million feddans in south Egypt (Tosky, oases and areas around Naser Lake), north Sinai (around El Salam Canal), east and west the Nile Delta as well as around the International Road

Using remote sensing images of different years, topographic maps, and the available data from governmental reports and literatures, Egypt was divided into six regions affected by different processes of desertifictaion namely oases, west Delta, Nile Delta and Valley, east Delta, north Sinai and the International Road. This study concluded that, the main factors of desertification in Egypt (arranged in decreasing order) are urban, sand dune movement, salinization, water logging, pollution and sea water intrusion. Sand dune movement is the main factors in south Egypt, north Sinai and west the Nile Delta. Water logging, salinization and urban are the main factors in the Nile Delta beside the salt water intrusion in the northern part. Pollution, salinization, water logging and urban are the main factors in east Nile Delta. Salt water intrusion, water logging and salinization are the main factors around the International Road.

INTRODUCTION

Desertification is defined as land degradation in arid, semi-arid and sub-humid areas resulting from adverse climatic condition and/or human impact. Desertification is not a new phenomenon, as many of the deserts can be no older than the late Cenozoic. Recently, numerous studies emphasize on the accelerating action of desertification due to misuse land by man. The FAO/UNEP (1984) defined the following six processes, which were considered in mapping desertification worldwide; vegetation degradation, water erosion, wind erosion, salinization, reduction in soil organic matter, soil crusting and compaction and accumulation of toxic substances in plants and animals. Other processes, having detrimental effects such as, urbanization of arable land, can be included. Forecasting desertification hazard can be made by combining the natural susceptibility and man- made factors. These factors include: climatic conditions, soils, topography, vegetation, animals, socio-economic land and water use, human biological parameters and social parameters.

In Egypt, 96% of its territory is desert, while about 65 million people live on the rest 4%. The inhabited land is even subjected to different desertification processes. Urban encroachment and dereliction of cultivated land surface resulted in disappearance of most fertile lands from productivity. Wind erosion and sand dune movements are active processes especially on the western desert oases, borders of the Nile valley and north and middle Sinai. (Abdel Hady et al., 1994; Abdel Samei et al., 1998 and Gad, 1999). Desertification due to salinization and water logging has a current and potential hazard in irrigated Nile valley and Delta (Abdel-Samie, 1998).

The continuous advances in remote sensing facilities and techniques have a great importance in the study of desertification, and factors affecting it. The value of remote sensing data depends on its nature and technical specifications. The space images, having fine resolution and satisfactory scale, allow detection and measurement of particular phenomena with high accuracy (Fig. 1). Moreover, the harsh weather conditions and lack of paved roads, which prevent travelling through desert, can be compensated by usage of remote sensing (Gad and Daels, 1985). Remote sensing is rather useful in this aspect at different scales.

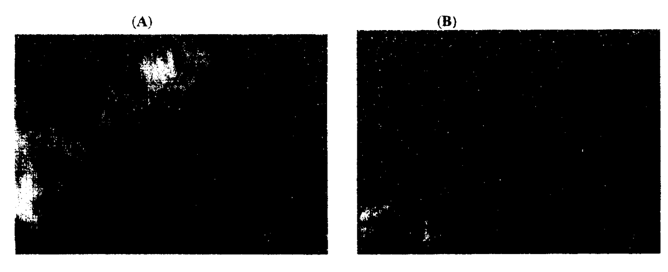


Figure 1. The change detection of the Toshka Lakes from December 1998 (A) to December 1999 (B).

Egypt was divided into six regions (Fig. 2) affected by different processes of desertifictaion namely oases, west Delta, Nile Delta and Valley, east Delta, north Sinai and the International Road. The main factors of desertification in Egypt (arranged in decreasing order) are urban, sand dune movement, salinization, water logging, pollution and salt water intrusion. Sand dune movement is the main factor in south Egypt, north Sinai and west the Nile Delta. Water logging, salinization and urban are the main factors in the Nile Delta beside the salt water intrusion in the northern part. Pollution, salinization, water logging and urban are the main factors in east Nile Delta. Salt water intrusion, water logging and salinization are the main factors around the International Road. All these factors are discussed below in detail.

MATERIALS AND METHODS

Two scenes were used mainly from two Thematic Mapper (TM) satellite images of 1987 and 1995. They were corrected using ERDAS IMAGINE software, and recent topographic maps were used as a reference. Two false color composites were produced for both sub-scenes, combination. The thermal band was excluded from LANDSAT-TM sub-scene in order to have high accurate classification. Both unsupervised and supervised classification technique was carried on all sences. The GIS system (ARC-INFO) was used to evaluate all the desertification processes.



Figure 2. Satellite image of Egypt shows the six regions.

The study of sand dunes density was carried out according to the change detection between two remote sensing images of different years and field measurements by some workers such as Gad et al. (2000) and Abdel Galil et al.(2000) that monitor the movement of the sand dunes. Analysis of soil salinity was based on Soil, Water and Environment Institute (SWEI) technical reports and Drainage Research Institute (DRI) technical reports (Yearbook Nile Delta 1986 and 1996). These analyses were used to construct salinity maps of the Nile Delta and detect the changes of salinity with time. But, the groundwater data were collected from Groundwater Research Institute technical reports (RIGW) and literatures such as Awad (1993) and Ahmed (1996). The provisional methodology of FAO/UNEP and UNESCO (1984) was adapted to evaluate status, rate and risk of desertification.

RESULTS AND DISCUSSIONS

1- Urban encroachment:

The high rate of human population growth and migration from rural areas to the urban centers lead to the more expansion of urbans on the best agricultural lands of high outcome. Farmers have been driven onto poorer quality lands, generating lower incomes. Thus, the growing incidence of rural poverty has been one of the leading factors driving desertification processes in the Egypt.

Twelve sites have been selected using recent remote sensing images and topographic maps compared with old photographic and remote sensing maps by Gad et al. (2000). It was possible to delineate the boundaries of each study site. The high resolution of the recent remote sensing images was quite helpful for the exact delineation of these boundaries. Area measurements of studied locations (table 1) made it possible to figure out a significant increase of urbanization with respect to the time interval.

Table (1): Average of urban areas monitored from aerial photographs and satellite images.

Governorate	Town or viliage	Area (feddans)		Difference (Feddans)	Percent	Annual Rate of increase	Rate of increase after Gad et al. (2000)
		1984	1995				
Cairo	Great Cairo	*** 45745	+78681	32936	72	6.0	4.8
Qalubia	Banha	*** 1111	+1817.6	706.6	63.6	5.3	4.6
	Tokh	*** 221	+343.0	122.0	55.2	4.6	3.2
	Kalub El Balad	*** 380	+740.2	360.2	94.8	7.9	6.8
	El Kom El Ahmr	*** 90	+152.6	62.6	69.6	5.8	4.4
	Basus	** 83.3	+356.3	273.0	327.7	29.8	20.5
El Monifia	El Baghour	* 25.5	+73.8	48.3	189.4	15.8	12.6
	Kafr El Museilha	* 180.4	+821.9	641.5	355.6	32.3	21.2
El Menia	Maghaga	* 386	+2347.6	1961.6	508.2	37.5	76.1
	Mallawi	** 170	+781.5	611.5	359.7	32.7	30.8
	Beni Amir	* 41.3	+135.5	94.2	228.1	19.0	16.7
	Beni Kaled El Bahana	* 54.6	+128.6	74.0	135.5	11.3	9.3

* Data of arial photographic in 1984 ** Data of arial photographic in 1985 *** Data of MSS satellite image in 1984 (Gad et al., 2000). + Data of TM satellite image in 1995.

The rate of increase ranges between 4.6 to 37.5% of the original areas. However, the magnitude of increase is more pronounced in smaller towns and in villages. This trend can be viewed as the rate of increase in Maghagha Town (37.5%), Mallawi Town (32.7%), Kafr El Muesilha (32.3), Basus (29.8), Beni Amir (19.0) and El Baghour (15.8). While, the rate decrease in the major cities that are 4.6 in Tokh, 5.3 in Banha, 6.0 in Great Cairo and 7.9 in Kalub El Balad. These results reveal that the aerial photographs and remote sensing images, with a satisfactory resolution are capable to insinuate the insight of very small areas.

The magnitude of increase depends on the strategic significance of location. The increase of the Great Cairo which is the capital of Egypt, great economic and administrative center reached to about 33,000 feddans during twelve years (Fig. 3). The percentage of increase reached 72% of its original coverage of 1984. Kalub

El-Balad, which is the geographical extension of Cairo City, attains an urban increase of 94.8% of its area, whereas this value represents about 360 feddans of land. Banha of highly fertile land in the middle of Nile Delta also is the capital of a prosperous province (Qalyubia) adjacent to Cairo to the North characterized by high rate of urbanization reach to 63.6%.

Table (2) shows the evaluation of status, rate and risk of urbanization in the studied locations, according to the modified FAO/UNEP provisional methodology (Abdel-Samie et al, 1990). The study areas are almost exposed to a very severe to severe status and rate of urbanization. All the areas face severe risk. These measures are based on the assumption that all urban expansion happened mainly on the cultivated fertile land. The estimation of the risk is based on a population increase of 1.2 million people per year. It is unfortunate that large areas of this expansion are in the form of scatter housing. This condition creates serious environmental hazard. Following a more controlled population policy may reduce the future risk of urbanization. This can come through a detailed study of people's socio-economic behavior.

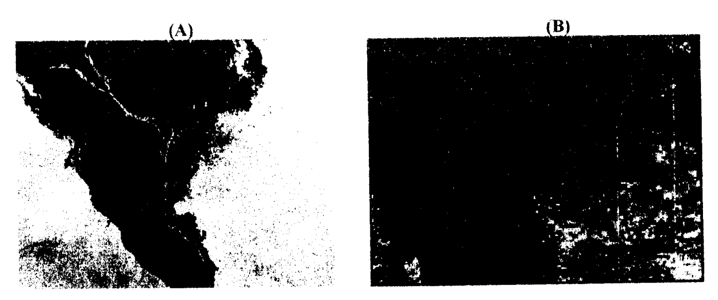


Figure 3. The change detection of the desertification by urban in Cairo from 1965 (A) to 1995 (B).

Table (2) Evaluation of different aspects of urbanization (according to FAO/UNEP, 1984).

Name of towns or village	Status		Rate		Risk	
	(1)	Class	(2)	Class	(3)	Class
Beni Amir	190.0%	V. Severe	19.0%	V. Severe	2-3%	Severe
Beni Kaled El- Baharia	113.0%	V. Severe	11.3%	V. Severe	2-3%	Severe
El- Baghour	158.0%	V. Severe	15.8%	V. Severe	2-3%	Severe
Maghagha	375.0%	V. Severe	37.5%	V. Severe	2-3%	Severe
Mallawi	327.0%	V. Severe	32.7%	V. Severe	2-3%	Severe
Basus	298.0%	V. Severe	29.8%	V. Severe	2-3%	Severe
Kafr El Meseilha	323.0%	V. Severe	32.3%	V. Severe	2-3%	Severe
Greater Cairo	60.0%	V. Severe	6.0%	V. Severe	2-3%	Severe
Banha	53.0%	V. Severe	5.3%	V. Severe	2-3%	Severe
Tokh	46.0%	Severe	4.6%	Severe	2-3%	Severe
El-Kom El Ahmar	58.0%	V. Severe	5.8%	V. Severe	2-3%	Severe
Kalub El Balad	79.0%	V. Severe	7.9%	V. Severe	2-3%	Severe

2- Sand dunes:

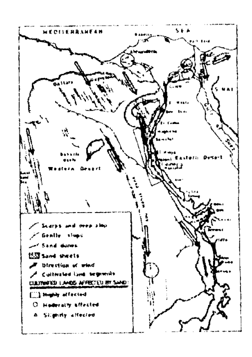
Active sand dunes cause serious problems in many parts of the world, especially in arid regions with loose, dry, sandy soils, low vegetative density and periods of strong winds. In Egypt the climatic conditions now characterized by arid with long hot rainless summer and mild winter with scarce amounts of rainfall encourage winds to become the main factors of erosion transportation and deposition of sediments. They cause sand accumulation as a sand dunes or sand movement in the cultivated lands. The wind data that obtained from the Egyptian Meteorological Authority (Table 3) and Figures (4 and 5) show that, the northern and northwestern winds are mostly prevailing throughout the year and affected the shape and

movement trend of sand dunes. But, in northern Egypt and Nile Delta region, wind pattern changes to SW - NE trend in winter. The mean wind speed reaches its highest value of 3.28 m/sec during winter on the northwestern coast, while the lowest value of 1.1 m/sec is recorded in autumn on the north eastern coast. Generally, blown winds possess highest velocity values on the northwestern coast, and lowest ones on the Delta region around the year. The speed categories below the threshold velocity of moving dry and loose sand (< 12 knot) are considered non-effective (Kadib, 1963; Fryberger, 1979; and Embabi, 1986-1987). The major accumulation of sand sheets and sand dunes in Egypt are those of the Great Sand Sea and Abu Moharik dune chains in the Western Desert and the small sand sea in north Sinai. They are belonging two generations: ancient dunes and recent ones as mentioned by Pye and Tsoar (1990) in North Sinai.

Table (3) Wind direction (D) and mean scalar wind speed (MSWS) in different regions of Egypt.

Region	Wind directions and velocity (km/h) in the four seasons							
	Winter		Spring		Summer		Autumn	
	D	V	D	V	D	V	D	V
North western Coast	SW	11.8	NW	11.1	NW	10.1	N-NW	8.3
North eastern Coast	SW	4.8	NW	4.9	NW	4.4	N	3.9
Nile Delta	SW	5.6	N-NW	7.0	NW	4.9	N	4.5
Western Desert	N	6.0	N	8.7	N-NW	8.4	N	8.7
Eastern Desert	NW	9.1	N	9.3	N	9.4	N-NW	9.2
Upper Egypt	N	8.0	N	9.3	NW	8.2	N	8.2
Cairo	S-SW	7.7	NE	8.7	NW	6.6	NE	7.1

D= Direction, V= Velocity



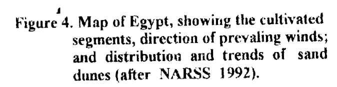


Figure 4. Map of Egypt, showing the cultivated segments, direction of prevaling winds; and distribution and trends of sand dunes (after NARSS 1992).



Figure 5. Wind blow in north west Egypt from the satellite image

Morphologically, dunes were classified according to Breed and Grow (1979) into three types of sand dunes namely linear dunes, transverse dunes and vegetated linear dunes (in order of abundance). The linear dunes range in length from several hundreds of meters to more than 5 km, and their heights reach to about 30 m. They forms nearly all sand dune belt in the Western Desert that take mainly the NW – SE direction. Transverse dunes are scattered in limited parts. According to Greely and Iverson (1985), transverse dunes are classified into three subcategories, namely: barchan dunes, barchanoids and transverse ridge dunes. Barchan dunes are characterized by low heights (up to 4 m), devoid of vegetation and tend to form in regions subjected to a single prevailing wind direction, where the supply of sand is somewhat limited. Barchanoid ridge dunes form where sand supply is greater than that of barchan dunes (Wasson and Hyde, 1983) as a complex chains, with a mean height of 3 m. Transverse ridge dunes are observed in many areas such as north El-Tasa region perpendicular to the prevailing wind attaining heights up to 15 m and overlie a sand sheet of scattered vegetation mounds. Vegetated linear dunes or stabilized linear dunes are generally characterized by low heights compared with the active linear dunes.

2.1 The distribution of aeolian deposits

Different cultivated areas were selected that affected by a variety of aeolian deposits. It was possible to analyze different environmental conditions in the following regions by using satellite images;

a) Coastal area:

The beach zone extends as a narrow strip from Rafah on the eastern border of Egypt to Alexandria in the west with a maximum width of 20 km. It is bordered in the south by cultivated lands and the northern lakes. They are mainly vegetated linear sand dunes with scattered traverse dunes. They are characterized by relatively low relief reach to about 8 m height and dense natural vegetation. They have non to slight effect on cultivated and new reclaimed areas.

b) The Nile valley:

The Nile Valley cultivated area was affected by the western sand dunes. There are plains and high rocky lands between the cultivated land and near sand dunes surface. The sand dunes are extended from south Aswan to El Fashn as a narrow strip increase in width northward to reach the maximum width south El Fayoum Depression which allow the movement and accumulation of sand dunes. They are of linear type parallel to the Nile Valley in additional to the existence of barchans especially on the western border of the Nile Valley. The barchans are more elongated with longitudinal seif in the eastern part of the dune. Their movement is from northwest to southeast direction. They are slight to severe effect on the cultivated land. This appear in the presences of sand deposits without forming dunes, and the abandoned irrigation and drainage canals in the cultivated land that are exposed to strong wind erosion.

c- Western Desert Oases:

The southern oases (El Kharga and Baris Oases) are highly affected by Abu Moharik sand belt, while the northern oases (i.e. El Baharia, and Siwa) are greatly influenced by the wind blown sands from the Great Sand Sea. The sand dunes are mainly of linear (longitudinal) type (Fig. 6) changed to barchan type near El Kharga Oasis due to the decrease in sand supply. The sand dune movement is slight to severe on most oases from the Great Sand Sea and Abu Moharik. While, in Dakhala Oasis is severe due to the sand movement from the high plateau bordering the oasis in the north (Fig. 7).



Figure 5. Satellite image shows the linear (longitudinal) sand dunes in the Western Desert.



Figure 6. Satellite image shows the sand movement from the high Dakhla plateau.

e) North Sinai sand dune belt.

The north Sinai region is characterized by a large accumulation of sand sheet and sand dunes that fornaing the small sand sea, which covers mainly the offshore plain. Transverse and barchan dunes are well developed in long belts. These sand dunes are generally dense in the area from south of El Bardawil Lake to Gebel El Maghara. They become less dense towards the east near El Arish and to the west. The prevailing wind direction responsible for the formation of sand dunes which are from northwest to southeast. While, they take southeast during winter in El Tina Plain and El Qantara Shark. The southeasterly sand drift is relatively higher than that towards northeast. This may explain that, locally severe, sand encroachment problems in the western sector.

2.2 Combating or mitigation of sand dune movement:

Spraying chemical stabilizers, which include bituminous, can stabilize the migrating sand dunes and lubrication oil however, unfriendly to the environment, thus physical and biological methods are preferable. The most common physical method is the use of sand fences. While, the

most common biological method is the cultivate of tolerant plants to the arid and/or saline conditions such as: *Tamarix aphylla*, *Acasia salicina*, *Panicum turgidum*, and *Retma raetam*.

3- Salinization:

The major problems that facing the irrigated soils are the development of salinity, and their negative effect on crop production. Where, salinization means lands containing more than 4 millimhos/cm at 25 C° in a 50 cm deep soil profile. It originates and develops as result of the evaporation of water solutions and the accumulation of precipitated salts in various layers of soil profiles and in the same solutions. The soluble salts in soils are mainly sodium chlorides with smaller concentration of magnesium chloride that migrate with river waters to the valley and Delta regions. While, the irrigation water salinity results from incorrect activities of man particularly through impeded drainage, insufficient leaching and / or incorrect use of saline water.

We can detect the qualitative changes of soil salinity in the Nile Delta and its fringes based on the assumption that salinity of drain water that collected from 1986 to 1996 as shown in table (4) and Figure (8).

Table (4): Changes in soil salinity in the Nile Delta and its fringes in 1996 in compared with 1986.

Soil salinity category	Range of drainage water (soil) salinity gm/m^3	Summary of qualitative changes from 1986 to 1996
1	750>	The area increases due to improvement especially in middle and west Delta. This appears in the increase of tile drainage from 1986 to 1996 (Fig. 9). While, the area decrease in the eastern part due to their dereliction into category 2.
2	750 – 1000	The area decreases in west and middle Delta due to improvement. This appears in the increase of tile drainage from 1986 to 1996 (Fig. 9). The tile drainage helped in leaching out excess water and salts from the soil, as well as significantly reducing the water table height. While, decreases in east Delta due to their dereliction into category 3.
3	1000 – 1500	The area increases due to the deterioration of category 2 into category 3 and the new reclaimed areas.
4	1500 – 2000	The area mainly increases in the west Delta part due to the new reclaimed lands and the improvement of category 5. While, decrease in the east Delta due to the improvement and the dereliction into category 5.
5	2000 – 3000	The area increases in the west an east Delta due to the improvement of category 6 and the expansion of new reclaimed areas.
6	> 3000	The area increases due to the new reclaimed areas especially from and around coastal lakes.

3.1 Combating salinization:

Salinization can be combating by the following methods that Establish and maintain of complete networks of open drains; cleaning of irrigation ditches; execute subsoiling of heavy – textured soils, compacted soils and profiles with impervious pans and leach out excessive salts as well as dense construct and maintenance the tile drainage.

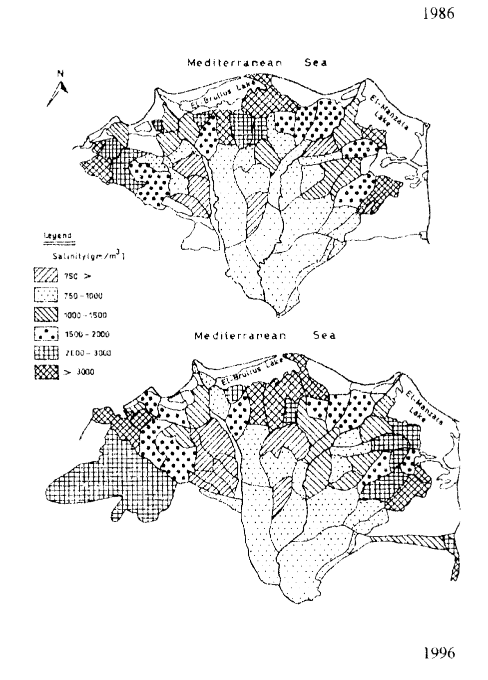


Fig. (8): The salinity changes of the Nile Delta and its fringes from 1986 to 1996.

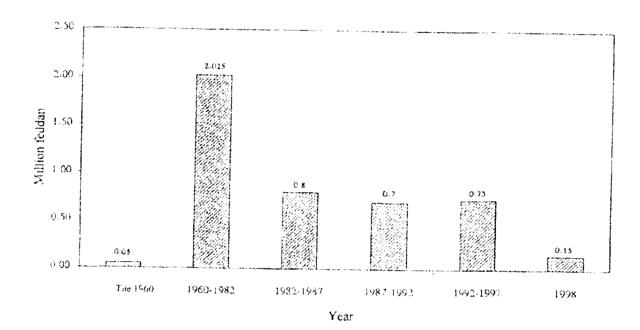


Fig. (9): The covered areas by tile drainage from 1950 to 1998.

4- Water Logging:

The construction of High Dam (1960 – 1968) eliminated the Nile seasonal floods and allowed agricultural lands to be brought under perennial irrigation. The natural drainage system that had sustained permanent agriculture for millennia could no longer cope with the increased percolation from irrigation, and large areas become water logged and salininized. Where, water logging means the water table is less than one meter deep from the soil surface at least 75% of the land.

The highly affected area by the water logging in Egypt is north Nile Delta. Where, their agricultural lands consist of an alluvial clay or silt resting on a deep sandy aquifer. Ground elevation ranges from + 4.64 m in the south to 0.87 m in the north and the depth to groundwater varied from 3.8 m in the south to 0.31 m in the north (Table 5). It can be divided into three areas according to the hydrogeological and hydrological conditions. The first one located in the eastern side of the Dameitta Branch that suffers upward seepage from the aquifer to the semipermeable surface bed. The second one located south middle Delta and west Delta that the groundwater levels decrease with time (Table 6). While, the third one is the coastal area of the Nile Delta in which the groundwater levels near the ground surface and increase with time (Table 6).

4.1 Combat the water logging:

We can combat the water logging by designing a new drainage network or modifying the present tile drainage system to excavate both excess irrigation and the upward seepage. Planting high tolerance crops to avoid water logging and salinization. Increase the quantity of fresh water discharge to keep sea water intrusion under control.

Table (5): The difference between the ground elevation and the groundwater level in the Nile Delta.

No.	Area	Well no.	Elevation (m)	Depth to water (m)	Difference (m)	No.	Area	Well no.	Elevation (m)	Depth to water (m)	Difference (m)
1	West Delta	275	2.55	1.65	0.9	10	Middle Delta	260	0.87	0.18	0.69
2		279	2.0	1.02	0.92	11		143	1.38	1.06	0.32
3		195	1.24	0.57	0.67	12		152	3.33	2.84	0.49
4		173	2.3	1.76	0.54	13		135	1.74	0.66	1.08
5	Middle Delta	156	2.54	3.39	2.15	14	East Delta	121	2.61	1.41	1.2
6		154	4.64	3.8	0.84	15		125	3.57	2.43	1.14
7		148	3.75	2.47	1.28	16		239	2.79	0.89	1.9
8		189	2.81	1.81	1	17		185	1.11	0.31	0.8
9		145	1.32	0.52	0.8						

Table (6): The changes of water table in north Delta between 1968 and 1996.

No.	Area	Well no.	Difference (m)	No.	Area	Well no.	Difference (m)	No.	Area	Well no.	Difference (m)
1	West	173	(-0.4) - (-0.32)	4	Middle Delta	143	(-0.02) - (-1.30)	7	Middle	159	(-0.01) - (-0.58)
2	Middle Delta	135	(+0.01) - (+0.52)	5		148	(-0.02) - (-0.75)	8	East Delta	125	(+0.02) - (+0.32)
3		146	(+0.2) - (+0.76)	6		152	(-0.02) - (-0.28)				

5- Pollution:

With the increase of population in the Nile Valley and Delta together with agricultural and industrial development has increase pollution of surface and groundwater. The main sources of pollutions are trace elements (heavy metal), Chemical Oxygen Demand (COD) and bacteria. The trace elements cause many diseases especially in liver, kidney and bone. While, some infective diseases as dysentery and typhoid may be result of bacteria pollution. Also, they affected the health of plants and animals even through they are in very small concentration.

5.1 Drainage water pollution:

Most of the drains in the Nile Delta suffer from a rapidly increasing deterioration of its water quality due to increasing discharges of heavily polluted effluents from municipal and industrial facilities. The pollution of the drain water was measured in nine areas that located nearly at the end of the drainage systems (Table 7).

In east delta, Serw drain receives drainage water from an area served of 66 000 feddans and domestic wastewater from Zarka Town (Damietta) as well as rural areas around the drain. Part of the drainage water is discharged to Damietta Branch and the remainder goes to lake Manzala While, New Bahr Hadus outfall water planned to pumped into El Salam Canal and the remainder goes to lake Manzala by gravity.

Table (7): The changes of drain water pollution in the Nile Delta.

Year	Area	Location	Position	TDS	Trace elements (ppm)						COD (mg/l)	Micro-biology (MPN/100 ml)
					Mn	Fe	Zn	Cu	Pb	B		
1996	East Delta	Serw P. St	Before	1330	0.04	0.23	0.01	0.01	0.02	0	118	1246117
			At	1395	0	0.14	0.01	0.01	0.02	0	109	18342250
		Bahr Hadus	At	2175	0.33	0.33	0.02	0.01	0.04	0	77.1	46600
	Middle Delta	Hamul P. St.	At	1348	0	0.19	0.03	0.01	0.01	0	101	480223120
			After	1338	0	0.14	0.03	0.01	0	0	122	484868860
		Drain No. 1	At	717	0	0.22	0.03	0.01	0.01	0	133	236600
	West Delta	Edko P. St.	Before	1075	0.1	0.19	0.05	0.01	0.02	0	250	245000
			At	990	0.04	0.13	0.02	0	0.01	0	152	49340
			After	774	0.07	0.08	0.01	0	0.01	0	149	44250

P. = Pumping St. = Station MPN= Most Probal Number

Drain No. 1 water pumped into Damietta Branch due to their relatively good quality, while Hamul Pumping Station supply Bahr Tira with most of Gharbia Drain water and the remainder goes to Mediterranean Sea in middle delta. Gharbia Drain receives domestic and industrial wastewater from El Mahala El Kobra and Tanta as well as wastewater of sugar industry in El Hamul Town.

While, Edko Pumping Station in west delta supply Mahmudeya Canal that feeds Alexandria City and the agricultural area with a portion of Edko Drain water and the remainder goes to the Mediterranean Sea through Edko Lake. It receives domestic wastewater from rural areas around the drainage water and from the agricultural area.

Manganese, iron, zinc, cupper and lead of the drain water in 1996 ranges from 0.0, 0.08, 0.0, 0.0 and 0.0 to 0.33, 0.33, 0.05, 0.01 and 0.04 ppm. While, the chemical oxygen demand (COD) ranges from 77.1 to 250 ppm, respectively. But, the microbiological content ranges from 44250 to 484868860 cell / 100 ml. These means that, the drain water are less polluted by trace elements, while highly polluted by microbiology. Thereby, the drain water must be treated before using in drinking and mixing it with irrigation water before using in irrigation.

5.2 Pollution in groundwater:

The main groundwater aquifer in the Nile Delta is the Quaternary aquifer. It is semiconfined aquifer, and composed mainly of coarse sand and gravel with occasional clay lenses. Their thickness varied from about 150 m in the south to more than 1000 m in the north. It is overlain by impervious clay and silt aquitard cap layer and underlain by clay layer belonging to Neogene. The water in the aquitard clay cap connected with the Quaternary aquifer through vertical flow in the form of downward leakage (infiltration) or upward seepage (groundwater logging).

Manganese, iron, zinc, lead, and nickel (Table 8) in the groundwater ranges from 0.19, 0.79, 0.10, 0.09, and 0.02 to 0.85, 11.52, 6.2, 0.72 and 0.23 ppm, respectively. This means that, the groundwater is polluted by these elements from the polluted surface water. We remarked that, the deep groundwater characterized by relatively high content than the shallow groundwater wells due to their presence with sediments in the aquifer. Thereby, the groundwater must be treated before using in drinking water, but suitable for irrigation. While, the groundwater is non polluted by cupper, cadmium and boron that range from 0.0, 0.0, and 0.30 to 0.38, 0.04, and 2.40 ppm, respectively. They are in safe range for drinking and irrigation.

The chemical oxygen demand (COD) that indicate the organic materials dissolved in water range from 39 ppm to 2389 ppm in the groundwater. Where, the high content was recorded in the northeastern part of the delta. The presence of excess COD affected by the presence of excess of some trace elements especially manganese and iron, where wells of high manganese and iron content have also a high COD values.

The groundwater is highly polluted by microbiological sources. They ranged from 3 in deep groundwater to >23 members / 100 ml in shallow groundwater well (Table 8). This means that, the shallow groundwater was highly polluted than the groundwater and the number of bacteria decrease with depth. The main sources of groundwater pollution are leakage from sewage system; septic tanks and chess pools; waste water and sludge treatment locations; animal wastes and surface water. The groundwater can not be used for drinking without treatment, but suitable for irrigation.

5.3 Combating the drain and groundwater pollution:

The domestic waste water of Zarka, El Mahalla El Kubra and Tanta Towns as well as the rural area must be treated before drain in the drainage system or mixing it with irrigation water. The trace element can be treated by different methods such as ionic removing method or mixing it with irrigation water before using. The drinking water must be chlorinated to remove the microbiological water pollution.

6- Sea water intrusion:

Sea water intrusion phenomena are considered as a dangerous problem with respect to irrigation, drainage and pollution. In the Nile Delta, there is hydrologic and geologic connection between the water bearing layers and the Mediterranean Sea. Generally, this connection can be either direct or indirect. When connection take places on the sea coast directly, the groundwater moves toward the sea and is drained directly through seepage on surface. Whereas, if the connection take place in land far from the sea, the groundwater drains indirectly as upward seepage. In the Nile Delta semiconfind aquifers, sea water intrusion in water bearing layer takes interior wedge form, where no seepage surfaces through which fresh

groundwater drain to the sea. But drains by upward seepage through the upper clay layer of the semiconfined aquifer.

Table (8): The pollution in groundwater in the Nile Delta.

No.	Well name from south to north	Elevation (m)	Total depth (m)	Depth to screen (m)	TDS	Trace elements (ppm)								COD	Micro-biology
						Mn	Fe	Zn	Cu	Cd	Pb	Ni	B		
1	Subk El Ahad	14.3	-63	-50	300	0.41	2.30	0.6	0.11	0	0.21	0.07	0.7	578	0
2	Kom El Dabaa	13	-40	-27	638	0.19	7.60	0.8	0	0	0.29	0.03	1.8	52	>23
3	Kamshush	11.9	-41	-30	670	0.82	11.2	0.8	0.02	0	0.29	0.03	0.8	1870	19
4	Shubra Kebala	12.2	-39	-28	619	0.68	1.25	0.3	0.03	0	0.15	0.04	1.2	1780	Nd
5	Kafr El Bagur	13.2	-22	-9.8	532	0.62	1.39	5.2	0.38	0.02	0.42	0.07	1.9	210	>23
6	Mit Bira	11.3	-23	-13	328	0.45	1.32	0.4	0.21	0	0.25	0.03	2.4	320	Nd
7	Quessna	10.7	-22	-11	371	0.19	4.85	1.3	0.03	0.04	0.18	0.02	2.2	120	3
8	Serena	10.2	-43	-31	685	0.60	1.64	0.3	0.18	0	0.15	0.03	Nd	Nd	11
9	Tanbisha	10.5	-34	-25	548	0.42	4.65	4.5	0.03	0.02	0.62	0.02	Nd	Nd	Nd
10	Tala	10.4	-38	-28	848	0.82	0.79	0.3	0.10	0	0.28	0.07	0.7	89	19
11	Kafr El Allawi	9	-21	-12	545	0.34	3.42	4.3	0.02	0.02	0.21	0.03	0.3	268	Nd
12	Mit Hibeish	8.4	-36	-29	749	0.85	11.52	0.8	0.18	0	0.18	0.23	0.4	2389	Nd
13	El Santa	8.8	-68	-60	1020	0.48	8.29	0.1	0	0.02	0.17	0.07	1.6	39	Nd
14	Kafr Kidr	7.8	-38	-42	508	0.53	1.95	7.1	0	0.03	0.21	0.08	1.8	668	4
15	Tanta	8.4	-68	-61	1010	0.59	8.31	0.3	0	0.02	0.20	0.09	1.2	75	5
16	Shubra El Namla	7.5	-23	-17	479	0.74	3.53	6.2	0	0.03	0.72	0.07	2.1	158	19
17	El Kanyisa	5	-50	-46	442	0.30	8.85	0.1	0	0.02	0.18	0.08	0.4	1876	Nd
18	Basyun	5.5	-36	-31	510	0.29	5.25	0.2	0.18	0	0.09	0.10	1.8	95	>23

Nd = Not measured

6.1 Combating the sea water intrusion:

To combat the sea water intrusion, construct main drain near the sea with bottom surface below the zero level and pump the excess of water to the sea.

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التصحر في مصر

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** معهد بحوث البيئة والتغيرات المناخية - وزارة الري.

انخطر الأكبر الذي يواجه مصر الآن هو الإدارة المثلى لمواردها المحدودة . بينما تواجه الأراضي الزراعية والأراضي تحت الاستصلاح مشكلة التصحر. تبلغ المساحة الزراعية في مصر حوالي ٨ مليون فدان تتواجد في معظمها حول الدلتا والوادي أما الأراضي تحت الاستصلاح تتركز جنوب مصر (توشكا - الواحات) ، شرق الدلتا ، غرب الدلتا ، شمال سيناء وحول الطريق الدولي الساحلي.

اعتمدنا في هذه الدراسة على صور الأقمار الصناعية لسنوات عديدة ، خرائط طبوغرافية ، البيانات المتاحة من التقارير الحكومية والبحوث المنشورة. تم تقسيم مصر إلى ٦ مناطق بناءا على أسباب التصحر هي الواحات ، غرب الدلتا ، الدلتا والوادي ، شرق الدلتا ، شمال سيناء والطريق الدولي الساحلي. تم استنتاج الأسباب الرئيسية للتصحر في مصر حسب أهميتها هي المباني ، زحف الكثبان الرملية ،الملوحة ، ارتفاع الماء الأرضي ، التلوث وتداخل مياه البحر. زحف الكثبان الرملية هو العامل الرئيسي للتصحر في جنوب مصر ، شمال سيناء وغرب الدلتا. بينما ارتفاع الماء الأرضي ، الملوحة والمباني هي العوامل الرئيسية للتصحر في الدلتا والوادي بجانب تداخل مياه البحر في الجزء الشمالي للدلتا. التلوث ، الملوحة ، ارتفاع الماء الأرضي والمباني هي العوامل الرئيسية في شرق الدلتا. ولكن تداخل مياه البحر ، ارتفاع الماء الأرضي والملوحة هي الأسباب الرئيسية للتصحر حول الطريق الدولي الساحلي.

An Attempt to Develop a System for Land Evaluation of Oxisols in Burundi

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ABSTRACT

An Applied System for Land Evaluation (ASLE) was developed and applied for some Burundi lands under different environmental conditions. The suggested system takes into consideration the main and dominant agricultural productivity factors in the rain fed agriculture of tropical humid regions. These factors include soil and fertility properties, water quality and environmental features. It suggests the calculation of the capability index and class. Moreover, it can be used to suggest soil improvement through the calculation of lime requirements. Application of this system was carried out on three sites selected from different regions, i.e., 1- Mwuriri and Cishwa hills, 2- Mugitega hills, 3- Kibungo hills. The obtained results showed that Mwuriri and Cishwa hills area was classified as Class 6 (non agricultural). Mugitega hills area; was classified into two land capability classes: Class 3 (fair) and Class 4 (poor). As for Kibungo hill, area was classified into two land capability classes: Class 3 (fair) and Class 6 (non agricultural). These classes were further classified into sub-classes, units and sub-units, which reflected the limiting productivity factors in the area. Results also indicated that limitations for land capability were the relatively, soil chemical properties as: high acidity, low CEC and high Aluminum toxicity; and soil physical properties as: very heavy texture (for one site). Low content of basic nutrients (Mg, Ca, K, P) and low levels of soil organic matter; were also indicated.

Keywords: Land evaluation, Acidity, Aluminum toxicity, land capability

INTRODUCTION

Land evaluation is a concept which describes the interpretation process of the principal inventories belonging to soil characteristics, vegetation cover, environmental conditions, climatic status and many other aspects related to the land, to identify the best land use among its alternatives (Sys, 1979). Generally, one of the principal objectives of land evaluation is to select the optimum land use for each defined land unit, taking into account both soil properties and socioeconomic consideration.

Generally, all evaluation systems are very similar in the concept, although there are differences between them in the factors, which they are based on. However, identifying factors considered through an evaluation system facilitates the comparison process of the advantages and disadvantages of various systems. Abdel-Motteleb and Hussein, 1985 (in Arabic), considered that soil characteristics and environmental conditions are the main factors of land productivity and classification.

In this system, six soil classes were introduced based on both soil properties and environmental conditions. Marei *et al.* (1987) proposed a computer

program for land evaluation system based on that of Abdel-Motelleb and Hussein (1985). This system was modified by El-Fayoumy (1989) to include soil fertility and irrigation water factors. The latest form of this system was developed (Morsy, 1994) by adding land suitability to different crops based on land properties as well as climatic data. Each factor was described as an index value to give its status in the percentage form. These indices were calculated using some empirical equations. The final index of land evaluation (F.I.L.E.) was calculated as: $F.I.L.E = \frac{4}{\frac{1}{S.I} + \frac{1}{E.I} + \frac{1}{W.I} + \frac{1}{F.I}}$

Where (S.I) is the soil index, (E.I) is the environmental index, (F.I) is the soil fertility index, and (W.I) is the irrigation water index. (Ismail *et al*, 1994).

The objective of this work is to establish a developed system for land evaluation and improvement, which suits different environmental conditions of Burundi. This system is based on a previous quantified land evaluation system talking into consideration four factors: soil characteristics, environmental conditions, soil fertility and rain fed water quality.

MATERIAL AND METHODES

Study areas:

Burundi is a part of the large physical ensemble of East Africa. It's latitude varies from 2^0 15' to 4^0 20' S and longitude from 29^0 to 30^0 50' E. Surface area is 28000 Km^2 Altitude varies from 770 to 2670 m. This variation leads to variation in climate, vegetation, and soil. Based on these variations, Burundi is divided into 11 natural regions. Kirimiro in the center of Burundi is one of these regions which dominated by steepy hills. The study area in Kirimiro is characterized by a humid tropical climate with wet and dry seasons. Average annual rainfall is about 1200 mm. The increment in precipitation is a function of altitude. Rainfall occurs in a bimodal pattern in April and November Definite dry season extend to 3 to 4 months during June, July, August and September. Mean annual temperature is 19^oC with a maximum of 25^o C and a minimum of 13^o C Soils are Oxisols with Haplohumox and Sombrihumox great groups formed on schist-quartzite parent material

Three areas were selected in KIRIMIRO region (center of Burundi), i.e., 1- Mwuriri and Cishwa hills, 2- Mugitega hills, 3- Kibungo hills. Each area is represented by two profiles as shown in Figures1, 2, 3, 4 and 5.

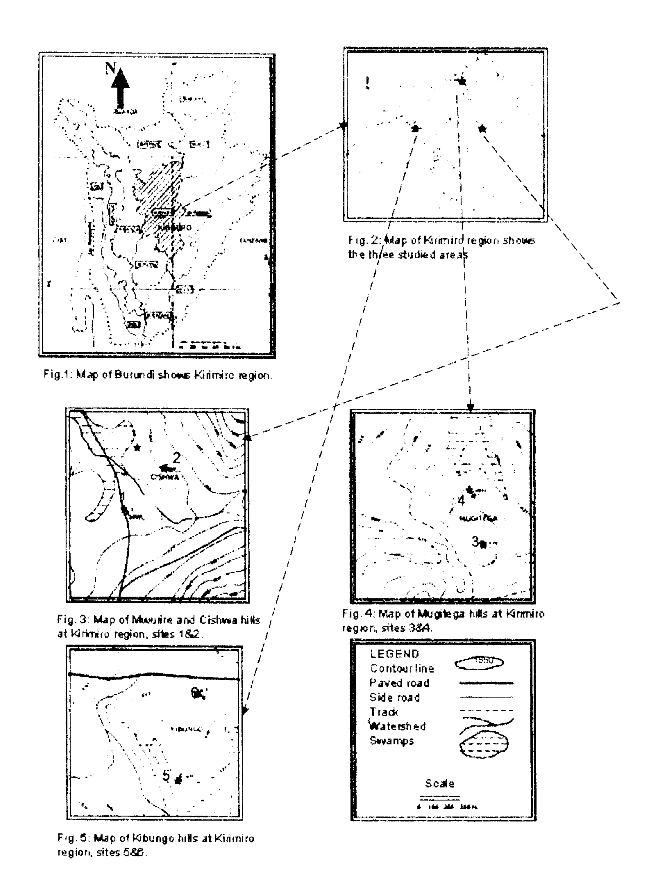


Fig.1: Map of Burundi shows Kirimiro region.

Fig. 2: Map of Kirimiro region shows the three studied areas

Fig. 3: Map of Mwuire and Cishwa hills at Kirimiro region, sites 1&2.

Fig. 4: Map of Mugitega hills at Kirimiro region, sites 3&4.

Fig. 5: Map of Kibungo hills at Kirimiro region, sites 5&6.

Field work:

Using topographic maps (scale 1:10000); six representative soil profiles (2 for each area) were dug in Locations of soil profiles were plotted. Soil layers were sampled according to the morphological variations for laboratory analysis of physical, chemical and nutritional soil properties (Page et al 1982).

Upgrading of Land Evaluation system:

Land capability was computed using the "Applied System for Land Evaluation" software that was developed by Ismail et al (2001) and upgraded by the authors to be suitable for Oxisols.

Adaptation of the land evaluation system may be summarized as follows:

1-Environmental conditions:

a) Crop rotation and land use system, Table 1 shows index values related to land use and crop rotation.

Table (1): Crop rotation and land use system.

Land use system	Index value %
1- Rotation	
With fallow	100
Without fallow	90
2- Association on with rotation	
With fallow	80
Without fallow	70
3- Association	
With fallow	65
Without fallow	60

b) Evaluation of soil conservation activity models according to different slopes, Table 2 shows soil and water conservation indices as related to different slope gradient.

Table (2): Index of soil and water conservation and watershed managements according to the slope classes.

Watersheds Management	Index
Class1: Slope from 0 – 12%	
Stabilizing grasses with permanently vegetative cover	100
Contour cultivation	90
Contour cultivation with natural cover	80
Natural vegetative cover	60
Without any conservation practices	50
Class 2: Slope from 12 –27%	
Terracing, Strip cropping with rock talus	75
Terracing, Strip cropping with rock talus and vegetation cover	70
Stabilizing grasses and vegetative cover on contour	65
Without any conservation practices, with natural legumes	30
Class 3: Slope from 27 –36%	
Flat terraces with legumes cover on slopping lands.	75
Flat terraces without legumes cover on slopping lands.	65
Contour cultivation with stabilizing grasses and vegetative cover.	60
Without any conservation practices, with natural legumes	20

Cont. Table (2): Index of soil and water conservation and watershed managements according to the slope classes.

Class 4: Slope from 36 –47%	
Flat terraces with cultivated trees and grass cover on slopping lands	70
Flat terraces with cultivated trees	60
Contour cultivation, Stabilizing grasses and vegetative cover	55
Without any conservation practices, with natural legumes	10
Class 5: Slope from 47 –65%	
terraces with permanent grasses	
Cultivated trees on terraces	65
Cultivated trees with natural grasses	60
Contour cultivation with Stabilizing grasses	50
Without any conservation practices, with natural legumes	5
Class 6: Slope more than 65%	
Covered with forests	60
Cultivated with legumes	5

2- Soil chemical properties:

a) Aluminum toxicity:

Oxisols are characterized by their high content of Al which causes toxicity hazard. So Kamprath index kl (Kamprath, 1983) is suggested to replace ESP used in sodic alkaline soils. Kamprath index values are presented in table 3.

$$KI = \frac{Al^{3+} * 100}{Teff}$$

Where: Teff. is sum of basic cations (Ca^{+2}, Mg^{+2}, K^{+}, Na^{+}) and acidic cations (Al^{+3}, H^{+}).

Table 3: The suggested index value of Kamprath index (KI).

KI (Kamprath Index)%	V.KI (Kamprath Index value %)
0 – 20	100 – 80
20 – 40	80 – 60
40 – 60	60 – 40
60 – 80	40 – 20
> 80	< 20

b) CEC:

Oxisol are characterized by their low content of CEC and high exchangeable acidity. This is a contrary with soils of arid environment. Table 4 shows acidity hazard index as related to CEC and soil pH values.

Table (4): Acidity hazard index value regarding to the requirements to correct the acidity depending on soil pH and C.E.C.

C.E.C	pH						
meq/100g	<4	4-4.4	4.5-4.9	5-5.4	5.5-5.9	6-6.5	>6.5
0 - 5	50	60	70	80	90	100	100
5 - 10	40	50	60	70	80	90	100
10 - 15	30	40	50	60	70	80	100
15 - 20	20	30	40	50	60	70	100
20 - 30	10	20	30	40	50	60	100
30 - 50	0	10	20	30	40	50	100
50 - 75	0	0	10	20	30	40	100
75 - 100	0	0	0	10	20	30	100
>100	0	0	0	0	0	0	100

3- Water quality index:

Comparing the arid zone irrigated land with tropical humid land with more than 700mm/year precipitation; water quality evaluation may be considered as a best value. So WI may equal 100%.Irrigation under arid conditions causes salinity hazards which reduces water quality index.

4- Soil improvement:

As oxisols are acidic, rich in Aluminum and poor in bases, they request improvement using lime as CaO or $CaCO_3$ to correct the excess of aluminum, low pH and low calcium. The next formula is suggested to calculate the quantities of lime requirements which have to be applied (Alterman et al, 1983):

$$CaO\ kg/ha = (306 - 59.64 * pH_{KCl}) * Clay\ \%$$

RESULTS AND DISCUSSION

1. Land capability:

Data of soil physical, chemical and fertility properties, as well as environmental conditions, are presented in Tables (5). These data were used to calculate soil index (S.I), fertility index (F.I) and environmental index (E.I). Water index (W.I) for the whole area, where annual precipitation is more than 1000 mm/year is quite enough for rain fed agriculture and considered as 100%.

Environmental conditions:

Rain fed agriculture is practiced through watershed management and soil conservation activity models used under different slopes. The area has an efficient natural drainage system due to deep ground water table. Artificial drainage is not practiced. Agronomic processes are good to moderate without mechanization. Roads are in good conditions and labor force is available. The dominant crops are field crops cultivated during the humid seasons. The entire areas are relatively secure and safe.

This information were used to calculate the environmental index (E.I.). However, there are no limiting factors concerning either environmental conditions or irrigation water quality.

Table(5): Data and Index values of land properties, final index and land capability classification of the studied profiles.

Property	Profile 1		Profile 2		Profile 3		Profile 4		Profile 5		Profile 6	
	Data	Index	Data	Index	Data	Index	Data	index	Data	Index	Data	Index
Clay%	81.63	30.60	86.71	22.13	72.14	46.42	71.66	47.22	99.97	0.03	67.79	53.87
S.F.	59.02	100.00	64.32	100.00	71.55	100.00	84.54	100.00	81.98	100.00	100.00	100.00
W.T.	>200	100.00	>200	100.00	>200	100.00	>200	100.00	>200	100.00	>200	100.00
A.W.	30.03	100.00	14.17	56.63	30.27	100.00	25.73	100.00	15.02	60.08	24.90	99.60
Perm.	4.83	67.00	2.52	76.50	3.14	84.00	7.77	69.50	2.12	71.60	3.95	94.50
Topogr.		73.60		72.80		69.60		71.20		61.60		76.00
P. depth	150.0	90.00	90.00	70.00	120.00	80.00	150.00	90.00	120.00	80.00	110.00	77.00
pH(H_2O)	4.30	0.01	4.90	0.01	4.70	0.01	5.20	8.00	4.20	0.01	5.80	32.00
pH(KCl)	4.10		5.20		4.20		4.80		4.00		4.70	
K.I.	75.75	25.00	36.50	64.00	49.67	50.50	27.00	73.00	72.00	27.50	2.33	98.00
C.E.C.	7.90	19.00	6.70	13.50	11.76	28.00	10.68	27.00	8.38	20.00	10.52	26.50
Acidity prob.		50.00		60.00		50.00		60.00		50.00		70.00
O.M.	2.40	40.00	1.05	17.50	3.15	52.50	2.78	46.33	1.99	31.67	2.86	47.67
C/N	14.30	71.36	7.00	100.00	13.60	74.54	12.13	81.22	10.00	90.90	12.67	78.76
OM&C/N		28.54		17.50		39.13		37.63		28.79		37.54
Nutrients		0.01		0.07		0.04		0.58		0.01		0.81
P.I.		75.18		64.98		80.40		80.03		25.12		84.07
C.I.		3.93		4.77		5.16		31.19		4.07		49.11
S.I.		2.95		3.10		4.15		24.96		1.02		41.29
S. Class		Six		Six		Six		four		Six		three
E.I.		76.60		75.90		66.40		78.10		68.50		78.10
(S&E)I		5.68		5.96		7.81		37.83		2.01		54.02
E&S Class		Six		Six		Six		four		Six		three
F.I.		5.34		6.89		8.85		16.93		5.37		18.38
W.I.		100.00		100.00		100.00		100.00		100.00		100.00
F.I.L.E.		7.28		8.12		10.55		32.8		3.24		40
Final Class		Six		Six		five		four		Six		three

Where:

S.F = Structure factor
W.T= Water table depth
A. W = Available water (%)
Perm. = Permeability (cm/h)
Topogr.= Topography index
P. depth=Profile depth (cm)

K.I. = Kamprath index
C.E.C.= Cation exchange capacity
O.M. = Organic mater (%)
P.I. = physical index (%)
C.I. = Chemical index (%)
S.I. = Soil index (%)

E.I. = Environmental index (%)
(S&E)I.= Environmental & soil index (%)
F.I. = Fertility index (%)
W.I. = Water index (%)
FILE = Final index of land evaluation (%)
Acidity prob. = Acidity problem (table 4)

Land capability classification:

The suggested land capability classification system was applied and the indices and capability classes were illustrated as in table (6)

Table (6): Suggested land capability classification system of the studied profiles illustrating the indices and capability classes unites and sub-unites.

Area	Site #	Soil index %	Classes, unites and sub-unites
Mwuriri and Cishwa hills	1	7.28	$C_6\,Sc_{pH,\,CEC,\,m,}\,F_{Mg,\,Ca,\,K,\,P,\,OM}$
	2	8.28	$C_6\,Sc_{pH,\,CEC;}\,F_{Mg,\,Ca,\,P,\,K,\,OM}$
Mugitega hills	3	10.55	$C_5\,Sc_{pH,\,CEC}\,F_{Ca,\,Mg,\,K}$
	4	32.80	$C_4\,F_{Ca,\,Mg,\,P}\,Sc_{pH,\,CEC}$
Kibungo hills	5	3.24	$C_6\,Sc_{pH,\,CEC\,m,}\,P_{t,}\,F_{Mg,\,Ca,\,K,\,P,\,OM}$
	6	40.00	$C_3\,F_{Ca,\,Mg,\,P,\,OM}\,Sc_{CEC,\,pH\,m}$

Note: the respective of limiting factors reflect the priorities of their effect on the productivity.

Final index (F.I.L.E.) for Mwuriri and Cishwa hills (site 1 and 2) was 7.28 % and 8.12 %, respectively. Consequently, the area is classified as class C_6 (non agriculture). Concerning land capability subclass, data revealed that soil properties and fertility status are the most limiting factors. Accordingly, $C6_{SF}$ subclasses were recognized in these areas.

Regarding land capability units, which represent the major limiting characteristics for land capability in this area, the following designations describe the land capability unit: C_6 Sc, F. Accordingly, the main limiting properties for land capability are some bad soil chemical properties and low soil fertility status. Two land capability sub-units were recognized, these are:

$$C_6\,Sc_{pH,\,CEC,\,m;}\,F_{Mg,\,Ca,\,K,\,P,\,OM}$$
$$C_6\,Sc_{pH,\,CEC,}\,F_{Mg,\,Ca,\,P,\,K,\,OM}$$

Where;

C_6	= Capability class 6.	Ca	= Calcium
S	= Soil properties.	Mg	= Magnesium
K	= Potassium	P	= Phosphorus
c	= Chemical soil properties.	C.E.C	= Cation exchange capacity
F	= Soil fertility.	m	= Kamprath index (IK)
OM	= Soil organic matter.		

consequently, the main limiting properties for land capability are: high acidity, low CEC and high Al-toxicity, as soil chemical properties; as well as extremely low available magnesium, calcium, potassium and phosphorus, and soil organic matter content and nutritional soil properties.

For Mugitega hills area, the final index was 10.55% and 32.8% for site 3 and 4, respectively. So, the area is classified as class 5 and class 4, respectively. Two land capability subclasses; C_5 S, F and C_4 F, S were recognized in this area.

Regarding land capability units, the following designations described two land capability unit:

$$C_5\ Sc;\ F$$
$$C_4\ F;\ Sc$$

Two land capability sub-units were recognized, these are:

$$C_5\ Sc_{pH,\ CEC;}\ F_{Ca,\ Mg,\ K}$$
$$C_4\ F_{Ca,\ Mg,\ P;}\ Sc_{pH,\ CEC}$$

Accordingly, for site 3, the main limiting properties for land capability were; soil chemical properties as pH and CEC; fertility status as available calcium, magnesium and potassium. However, limiting factors for site 4 were fertility status as: available calcium, magnesium and phosphorus and chemical soil properties as: pH and CEC.

For Kibungo hills area, the final index was 3.24% and 40% for site 5 and 6, respectively. The area is classified into classes C_6 and C_3. Two land capability subclasses; C_6 S; F and C_3 F; S were recognized.

Regarding land capability units, the following two formulas describe the land capability units:

$$C_6\ Sc;\ p;\ F$$
$$C_3F;\ Sc$$

Two land capability sub-units were recognized, these are:

$$C_6\ Sc_{pH,\ CEC,\ m;}\ p_{t;}\ F_{Mg,\ Ca,\ K,\ P,\ OM}$$
$$C_3\ F_{Ca,\ Mg,\ P,\ OM}\ Sc_{CEC,\ pH,\ m}$$

Where:
p =Physical properties
t =Texture

Accordingly, the main chemical soil properties for land capability of Kibungo hills area at site 5 were low pH, low CEC and high Al-toxicity. Extremely heavy texture was a limiting physical soil property. Soil fertility was recognized as low available Mg, Ca, K, P and low organic matter content. While for site 6 the situation was varied, where its productivity limiting factor was fertility (low available Ca, Mg, P and low organic matter content), and soil chemical properties as low CEC, pH, and high Al-toxicity.

In conclusion, the data showed significant differences in land capability sub-units between areas and sites.

II. Soil Improvement:

<u>Soil acidity:</u>

Lime requirements were calculated for each site to improve soils acidity, taking into consideration the acidity tolerance of grown crops. Results indicate a

wide variation between different studied areas, as well as inside the same area (table 7).

Table (7): Lime requirements based on pH and clay content for the studied soils (kg/ha)

Area	Site	pH	clay%	CaO	CaCO3
Mwuriri and Cishwa hills	1	4.10	67.76	4223.89	7065.14
	2	4.60	66.81	2172.39	3633.67
Mugitega hills	3	4.15	70.01	4155.37	6950.53
	4	4.55	58.84	2088.7	3493.69
Kibungo hills	5	4.00	90.18	6159.29	1030.41
	6	4.75	48.85	1151.39	1925.89

Lime requirements ($CaCO_3$) of the studied soils varied between 1.03 to 7.06 ton/ha mainly according to clay content variation rather than pH variation. Concerning the first location (prof.1), lime requirement. was 7.06 ton/ha, while it was about 1/2 this quantity (3.6 ton/ha) for site 2 of the same area . The second area needs lime addition about 7.0 ton/ha for site 3, whereas it was also about 1/2 the last quantity (3.5 ton/ha) for site 4. In the last area the lime requirement is ranged between 1.03 and 1.9 ton/ha for sites 5 and 6, respectively.

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الملخص العربي

محاولة لتطوير نظام لتقويم أراضي الأوكسيسول ببوروندي

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يهدف هذا البحث إلى إنشاء نظام لتقويم كمي لبعض الأراضي البوروندية تحت ظـروف بيئيـة متباينـة، وذلك من خلال تحديد العوامل الإنتاجية الزراعية بالمنطقة (خواص الأرض، جودة مياه الأمطار، الخصـوبة، والعوامل الاجتماعية والاقتصادية). ومن خلال التحكم في هذه العوامل يمكن الارتقـاء بالمسـتوى الإنتـاجي للأرض.

لتطبيق هذا النظام، تم اختيار منطقة ممثلة لبعض أراضى أوكسيسول فـي منـاطق الـتلال البوروندية الاستوائية ، وتم تصنيف مستويات المقدرة الإنتاجية لأراضى مناطق الدراسة.

تم حساب الدليل لكل عامل من عوامل الإنتاجية الزراعية كتعبير مباشر عن حالته التقويمية، ومن خـلال هذه الأدلة تم حساب الدليل النهائي لتقويم الأراضي المعبر عن درجة القدرة الإنتاجية للأرض. وقـد أظهـرت النتائج أن:

منطقة Mwuriri and Cishwa hills:

الدليل النهائي لتقويم الأرض يتراوح بين ٧,٢٨ – ٨,١٢ % مما جعل المنطقة تقع داخل قسم من أقسـام القدرة الإنتاجية الأرضية وهو Class 6 وهو يعبر عن القدرة الإنتاجية المنخفضة جداً (غير زراعيـة). وقـد تم تقسيم المستويات العليا للتقويم إلى مستويات أدنى هي مستوى تحت قسم Subclass ثم مستوى وحـدة Unit ثم مستوى تحت وحدة Subunit وبزيادة الاتجاه نحو مستويات التقويم الدنيا تتكشف العوامل المحـددة للقـدرة الإنتاجية الزراعية وتقع كلها تحت مجموعة الخصائص الأرضية وتشمل: الانخفاض الواضح لمحتوى التربـة من المادة العضوية والمغذيات الكبرى.

منطقة Mugitega hills:

الدليل النهائي لتقييم الأرض يتراوح بين ١٠,٥٥ – ٣٢,٨ % مما جعل المنطقة تقع داخل قسمين من أقسام القدرة الإنتاجية وهما:

أ- Class 3 وهو يعبر عن القدرة الإنتاجية المتوسطة.

ب- Class 4 وهو يعبر عن القدرة الإنتاجية الحدية.

كانت العوامل المحددة للقدرة الإنتاجية تتبع خواص الأرض والانخفاض الواضح لمحتوى التربة من المادة العضوية والمغذيات الكبرى.

منطقة Kibungo hills:

الدليل النهائي لتقييم الأرض يتراوح بين ٣,٢٤ – ٣٩,٩٦% مما جعل المنطقة تقع داخل قسمين من أقسام الإنتاجية الأرضية وهما:

أ- Class 3 وهو يعبر عن الإنتاجية المتوسطة.

ب- Class 6 وهو يعبر عن الإنتاجية المنخفضة جداً (غير زراعية).

كانت العوامل المحددة تتبع خواص الأرض الفيزيائية (قوام التربة) والكيميائية وخصوبتها والتي تشمل: الانخفاض الواضح لمحتوى التربة من المادة العضوية والمغذيات الكبرى.

وسائل رفع إنتاجية الأراضى في منطقة الدراسة:

قد أوصى البرنامج المطور والمقترح عند استخدام نظام تقييم الأراضي بحساب الاحتياجات الجيرية اللازمة لتحسين خواص الأرض والمحافظة عليها من التدهور، بدرجات متفاوتة محسوبة بناءاً على درجة **حموضة الأرض** (pH_{KCl}) ونسبة الطين وذلك باستعمال معادلة Alterman et al (1983) .

Technical session 2:
Soil Pollution and Soil Fertility:

- *A.F.El-Aswad[1] and Ramzy M.R.Hedia[2]*
  "Fate and behavior of Aldicarb under Egyptian soil conditions: I.Sorption/Desorption kinetics and soil-bound residues"
  (1.Pesticide Chemistry Dept.;
  2.Soil and Water Sci.Dept., Fac.Agric.,El-Shatby, Alex.Univ.)
- *M.H.El-Sayed and S.E.Mahrous*
  "Environmental assessment of soil and plant pollution caused by industrial activities of Abou Zaabal area in Egypt"
  (Soils, Water, and Environment Res.Inst., Agric.Res.Center)
- *Somaya,A.Hassanein, N.F.Kandil, M.A.Abu Sinna, S.S.Behiery, Samira E.Mahrus and N.M.El-Mowelhi*
  "Environmental assessment of drainage water in Nile Delta for sustainable agricultural development: I.Salinity hazards"
  (Soils, Water, and Environment Res.Inst., Agric. Res.Center)
- *Somaya A.Hassanein, M.A.Abu Sinna, N.F.Kandil, B.M.El-Nashar and N.M.El-Mowelhi*
  "Environmental assessment of drainage water in Nile Delta for sustainable agricultural development: II.Elements hazards"
  (Soils, Water, and Environment Res. Inst., Agric. Res. Center)
- *Somaya A.El-Hassanein, N.F.Kandil, M.A.Abu Sinna, H.A. Ramadan, M.E.El-Fayoumy and N.M.El-Mowelhi*
  "Environmental assessment of drainage water in Nile Delta for sustainable agricultural development: III.Public health hazard"
  (soils, Water, and Environment Res.Inst., Agric.Res.Center)
- *W.E.Ahmed and T.A.El-Maghraby*
  "Techniques effect of Phosphorus fertilization on zinc uptake in wheat plants "Triticum aestivum" at different growth stages and availability in soil"
  (Soils, Water, and Environment Res.Inst., Agric.Res. Center)

Fate and Behavior of Aldicarb under Egyptian Soil Conditions. I. Sorption/Desorption Kinetics and Soil-Bound Residues.

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ABSTRACT

For a better understanding of the environmental fate and behavior of aldicarb under the Egyptian soil conditions, a study on the kinetics and isotherms of adsorption/desorption of aldicarb by five different Egyptian soil types was carried out. Batch experiments using 1:10 soil:solution suspensions and aldicarb concentration series of 0, 5, 10, 20, 30 and 40 mg L^{-1}(a.i.) were conducted. A background solution of 0.01*M* $CaCl_2$ was used. The equilibrium time was found to be 1.0 h. Soils with high OM and clay contents confirmed to the S-type isotherm while soils with low OM content represented typical C-type isotherms. The isotherms obtained generally confirmed to the Freundlich adsorption equation with a correlation coefficient r > 0.95. The greater adsorption (larger *K* value) of aldicarb by the Abis soil has been attributed to a higher OM content. According to *K*, K_d and K_{om} values, the affinity of the studied soils to aldicarb adsorption can be in the order Abis = Abou El-Matamir > El-Sadat > Burg El-Arab > Nubaria. Soil-bound aldicarb residues represented an average of 87% in Abis, Abou El-Matamir and El-Sadat soils, 74.5% in Burg El-Arab soil, and 6.1% in Nubaria soil.

INTRODUCTION

Large amounts of pesticides are used in modern agriculture. Major challenge today is to develop satisfactory techniques that combine optimum production with environmental protection (Buelke *et al.*, 2000; Mbuya, *et al.*, 2001). The fate of pesticides in soil environment is governed by various transport, retention and transformation processes. These processes determine both the efficacy of pesticides in controlling target organisms and their potential for adverse effects on nontarget organisms. Although retention includes all processes that prevent or retard movement of pesticides in soils, the primary means of retention is adsorption of pesticides on soil constituents (Koskinen and Harper, 1990; Laird *et al.*, 1992). Also, sorption of pesticides in soil or other porous media is recognized to be an important process regulating pesticide transport and degradation in the environment (van Genuchten and Wagenet, 1989; Wagenet and Rao, 1990; Lei Guo *et al.*, 1999). Moreover, the mathematical description of the sorption phenomena between solute and sorbent is one of the critical components of all transport models. In describing the adsorption-desorption process, transport models usually assume either an equilibrium or kinetic relationship (Harmon *et al.*, 1989; Gaber *et al.*, 1992).

The negative correlation between sorption and mobility has been well-established (Pignatello *et al.*, 1993; Soutter and Musy, 1999). However, the effect

of sorption on degradation is much more complicated and depends on many factors related to microbial, soil and environmental conditions as well as the properties of the chemical of interest (Alexander, 1994). Adsorption of pesticides by soils and their constituents has been investigated by several authors (Kaufman *et al.*, 1976; Calvet et al., 1980; Gaber *et al.*, 1992). Studies on the adsorption and mobility of pesticides in soil have so far focused on herbicides in preference over insecticides (Arienzo *et al.*, 1994)

An array of equilibrium-based models have been used to describe adsorption on soil surfaces (Sparks, 1995). These include the widely used Freundlich equation, a purely empirical model, the Langmuir equation and double-layer models including the diffuse double-layer. Since most published work deal with equilibrium situations, little information exists about the kinetics of adsorption-desorption phenomena. Kinetic studies on soil pesticide systems are generally made by measuring the composition of the solution phase. Adsorption equilibrium is attained within 24h in general. This holds for suspensions but may not be valid for systems with low water contents. However, desorption is usually slower than adsorption, but its kinetic characteristics are less well known (Calvet, 1980). The influences of soil parameters that affect the adsorption of pesticides such as organic matter, type and amount of clay, pH, moisture status, and soil temperature have been investigated by several authors (Aly and Bakry, 1986; Aly *et al.*, 1987; Arienzo *et al.*, 1994; Richter *et al.*, 1996; Gonzalez-Pradas *et al.*, 1999).

Aldicarb [(Temik): 2-methyl-2-(methyl thio) propionaldehyde-o-methyl carbamoil oxime] is widely used as an insecticide and nematicide for variety of crops, including potatoes, peanuts and citrus. Little is known about the kinetics of retention and soil-bound residues of aldicarb is limited under Egyptian soil conditions (e.g. Aly, 1987; Aly *et al.*, 1987). Our objectives were to study; i) the sorption kinetics of aldicarb in five different Egyptian soil types, ii) the adsorption/desorption isotherms and the derivation of its parameters, and iii) the formation of the soil-bound residues.

MATERIALS AND METHODS

1- Soil Characterization:

Five different soil types were chosen to represent the most common Egyptian soil types in northwest of Delta. Surface disturbed soil samples (0-30 cm) were collected from Abis, Abou El-Matamir, El-Sadat, Burg El-Arab and Nubaria regions. Air-dried soil samples, less than 2 mm particle size, were analyzed by standard methods according to Klute (1986). The pH was determined in a 1:2.5 soil/water suspension using a glass electrode, electrical conductivity of

the soil paste extract by an EC-meter, organic matter content (OM) by the Walkly-Black method, particle size distribution by the hydrometer method, cation exchange capacity (CEC) by the ammonium acetate method and total carbonate by calcimeter method. All these characteristics are shown in Table (1).

2- Kinetics of Aldicarb Adsorption:

A batch experiment was conducted to determine the equilibrium time of aldicarb adsorption on soils. Aqueous calcium chloride background solution (0.01*M*) containing initial concentration (C_o) 20 mg L^{-1} a.i. of analytical-grade aldicarb (100%) was used. A 1:10 (soil:solution) aqueous suspension was placed in a stoppered 50-ml centrifuge tube and shaken for 0.08, 0.5, 1.0, 3.0, 6.0, 12.0 and 24.0 h at 25±1 °C. After shaking on a horizontal shaker (Heidolph Promax 1020) at 150 rpm, solutions were centrifuged at 9250g for 15 min (REMI Lab. Centrifuge R32A). and the concentration aldicarb in the supernatant was determined colorimetrically (Sequoia-Turner Corp. Model 390 Spectrophotometer) according to the method described by Meagher *et al.* (1967), a procedure which was slightly modified by Aly (1977) to increase its sensitivity. The aldicarb sorbed was calculated from the difference between the initial and the final solution concentrations. Blanks containing no aldicarb and three replicates of each sorption point were used.

The sorption experiments were carried out using the same background solution and the initial aldicarb concentrations 0, 5, 10, 15, 20, 30, 40 mg L^{-1} a.i. Aqueous soil: solution suspensions were shaken for the appropriate equilibrium time determined from the kinetic batch experiment. Blanks with no soil indicated that adsorption of aldicarb to reaction vessel was insignificant.

Table (1): Main chemical and physical characteristics of the studied soils

Characteristics	Soils				
	Abis	Abou El-Matamir	El-Sadat	Burg El-Arab	Nubaria
pH (1:2.5)	7.67	8.14	7.98	8.38	8.41
E.C. (dS m^{-1})	1.29	1.72	1.07	2.84	1.01
$CaCO_3$ (%)	9.5	6.62	5.81	42.60	5.56
OM (%)	2.58	1.48	0.55	0.76	0.10
CEC (cmole$_c$ kg^{-1})	37.73	29.29	6.61	6.38	2.02
Clay (<0.002 mm %)	35.37	20.80	15.49	20.45	7.46
Texture Class #	SCL	SL	SL	SCL	S

#: S= Sandy SL= Sandy Loam SCL= Sandy Clay Loam

3- Desorption of Aldicarb from Soils:

Desorption experiments were carried out by adding aqueous $CaCl_2$ solution (0.01*M*) to the stoppered centrifuge tubes after removal of the sorption supernatant. This system was shaken again to establish the new equilibrium followed by centrifugation and determination of the new equilibrium concentration in the supernatant. The amount of aldicarb desorbed in the first equilibration was calculated. This process was repeated for one time with the same $CaCl_2$ solution and another time using acetone as a nonpolar solvent to assess the soil-bound residues. The quantity of desorbed aldicarb was corrected for the amount in the solution left with the soil in the centrifuge sediment, taking into account the final concentration of the solution and the weight of retained solution.

4- Characterization of the Adsorption Isotherm:

Aldicarb adsorption was described by the Freundlich equation:

$$Q = KC^{1/n}$$

where Q is the quantity of aldicarb adsorbed per gram of adsorbent (mg kg^{-1}), C is the equilibrium aldicarb concentration in solution (mg L^{-1}), K is the distribution coefficient (L kg^{-1}) and $1/n$ is a constant.

RESULTS AND DISCUSSION

Data of the equilibrium state of aldicarb adsorption by the studied soils are shown in Figure (1). The equilibrium times obtained varied slightly between soils but they were all within the first 1.0 h. Thereafter, the concentration of the adsorbed chemical was almost constant up to 24 h shaking. The time required for a pesticide-soil system to reach an adsorption equilibrium depends on the type of pesticide and the soil characteristics (von Oepen *et al.*, 1991; Nkedi-Kizza and Brown, 1998). Therefore, an equilibrium time of 1.0 h was used in the subsequent adsorption and desorption experiments.

The adsorption isotherms of aldicarb by soils showed different forms according to soil characteristics (Fig. 2). Those for soils with the highest OM and clay contents (Abis 2.58% and 35.37%; Abou El-Matamir 1.48% and 20.80%, respectively) were S-type (initial convex curvature) according to the classification of Sposito (1984); this reflects a low adsorbent-adsorbate affinity at low concentrations. Although the initial concave and convex curvatures of the isotherms obtained in this work were smooth (all of them approach type C), their shapes showed that the affinity of the soils for aldicarb was related to their organic matter content. This finding is supported by the results obtained by Saint-Fort and Visser (1988) and Nkedi-Kizza and Brown (1998). The rest three soil types represent typical C-type isotherms. However, El-Sadat soil showed higher

affinity to aldicarb compared to the highly calcareous Burg El-Arab soil (42.6% $CaCO_3$). This may suggest that calcium carbonate blocks the adsorption sites available for aldicarb. Madsen *et al.* (2000) did not observe any correlation between the distribution coefficient (K_d) of seven different pesticides in ten different-origin soil types and their total inorganic carbonate. Due to its very low OM (0.1%) and clay content (7.76%), Nubaria soil practiced a very weak affinity to aldicarb adsorption.

The isotherms obtained generally confirmed to the Freundlich adsorption equation with a correlation coefficient r > 0.95 (Fig. 3). As can be seen in Table (2), for Abis soil, K=103.4 and $1/n$= 0.95, and for Nubaria soil, K= 8.57 and $1/n$= 0.89. These values are consistent with the adsorption characteristics previously discussed. The greater adsorption (larger K value) of aldicarb by Abis soil has been attributed to a higher OM content. These results are in agreement with those obtained by Koskinen and Harper (1990) and Sanchez-Martin and Sanchez-Camazano (1991). The distribution coefficient, K_d, represents adsorption at equilibrium concentrations higher than K, and is defined as the ratio between the pesticide concentration in the soil and that in the equilibrium solution at a given equilibrium concentration (K_d was calculated for C_o= 3.0 mg L^{-1}). Finally K_{om} is the K value normalized for 100% organic matter [K_{om} = 100 x (K/%OM)]. Log K_{om} values, which are very frequently used as a measure of the pesticide adsorption capacity of soils ranged from 3.59 to 4.13. This range was quite narrow. The average log K_{om} values are similar to that obtained by other authors (Green and Karickhoff, 1990; Arienzo *et al.*, 1994). Accordingly, the affinity of the studied soils to aldicarb adsorption can be in the order Abis = Abou El-Matamir > El-Sadat > Burg El-Arab > Nubaria.

Results of two-steps aldicarb desorption from soils are presented in Figure (4). Aldicarb concentrations at the first desorption equilibrium were reduced to about 1/4 and to about 1/10 in the second desorption of that obtained in the adsorption experiment. This indicates that the soils retained most of the adsorbed aldicarb and that the adsorption is an irreversible process. Many authors reported that it is often observed that desorption is a more difficult process than adsorption and that not all of the adsorbate is desorbed (Verburg and Baveye, 1994; Sparks, 1995).

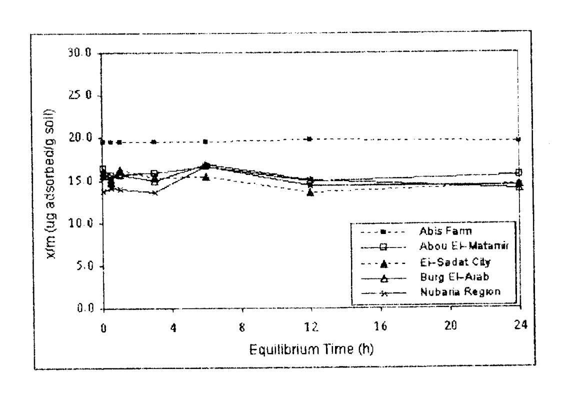


Figure (1): Equilibrium time of aldicarb adsorption on different soil types.

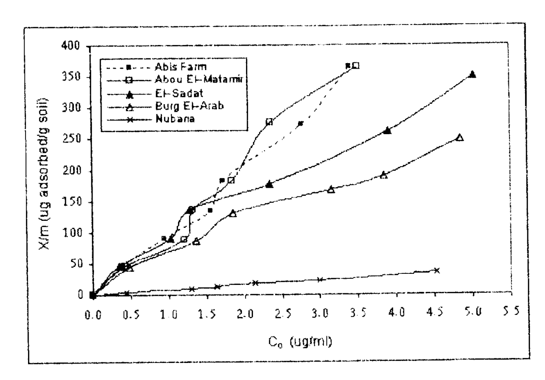


Figure (2). Adsorption isotherms of aldicarb for different soil types. different soil types.

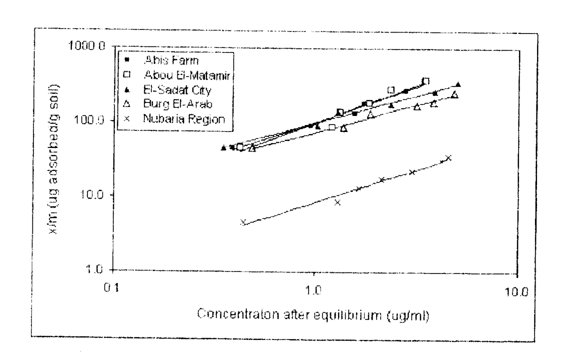


Figure (3): Fitted Freundlich adsorption isotherms of aldicarb for different soil types.

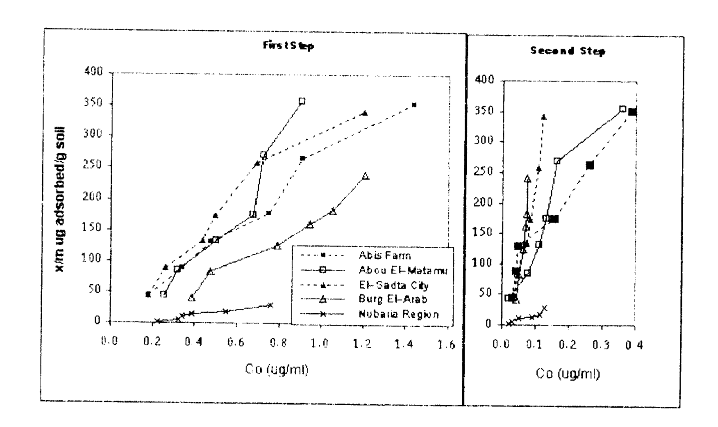


Figure (4):First and second-step desorption isotherms of aldicarb from different soil types.

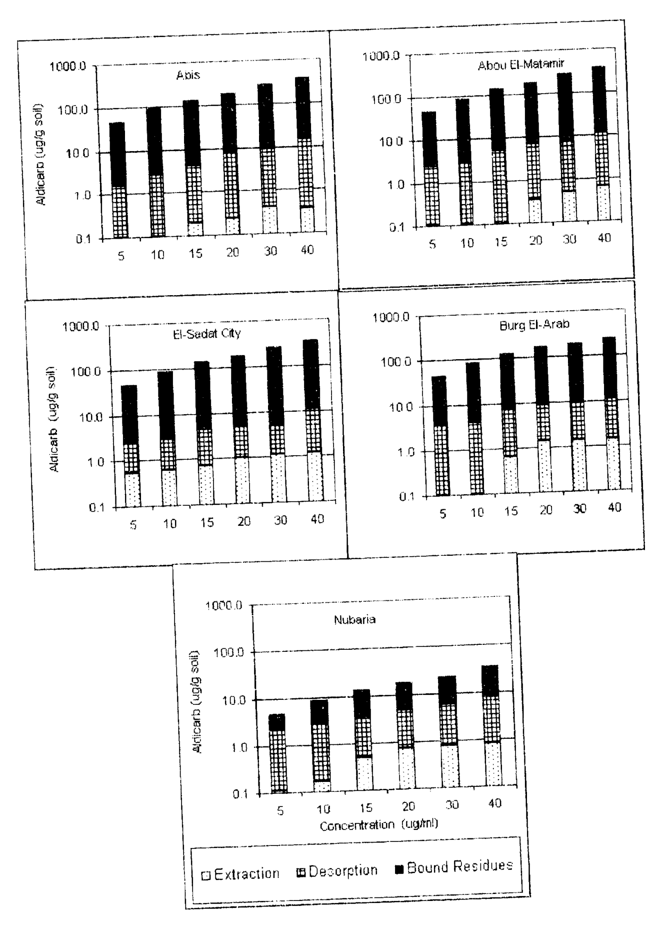


Figure (5):Distribution of aldicarb among d+K22esorbed, extracted and

soil-bound residues.

Table (2): Freundlich isotherm parameters, distribution coefficient (K_d) and log K_{om} of aldicarb for five different Egyptian soil types.

Soils	K	1/n	r	K_d	Log K_{om}
Abis	103.4	0.95	0.981	100.5	3.59
Abou El-Matamir	98.4	1.03	0.953	101.2	3.83
El-Sadat	99.1	0.74	0.984	74.8	4.13
Burg El-Arab	75.1	0.73	0.987	55.7	3.81
Nubaria	8.6	0.89	0.975	7.6	3.88

The distribution of aldicarb among desorbed, acetone-extracted and soil bound residues are exhibited in Figure (5). It can be noted that the amounts of acetone-extracted aldicarb from Abis, Abou El-Matamir and Burg El-Arab were negligible at low equilibrium concentrations. Soil-bound aldicarb residues represented an average of 87% of the applied aldicarb in Abis, Abou El-Matamir and El-Sadat soils and 74.5% in Burg El-Arab soil. While, Nubaria soil recorded only an average of 6.1% soil bound residues. It was reported that the bound residue expressed as percent of applied ranged from 7 to 90% (Anonymous, 1975; Khan and Dupont, 1987; Fuehr, 1987; El-Aswad, 1998).

CONCLUSION

The equilibrium times of aldicarb in the studied Egyptian soil types were all within the first 1.0 h. Soils with high OM and clay contents represented the S-type isotherm while soils with low OM content represented typical the C-type isotherms. The isotherms obtained generally confirmed to the Freundlich adsorption equation with a correlation coefficient $r > 0.95$. The greater adsorption (larger K value) of aldicarb by the Abis soil has been attributed to a higher OM content. According to K, K_d and K_{om} values, the affinity of the studied soils to aldicarb adsorption can be in the order Abis = Abou El-Matamir > El-Sadat > Burg El-Arab > Nubaria. The adsorption is an irreversible process. Soil-bound aldicarb residues represented an average of 87% in Abis, Abou El-Matamir and El-Sadat soils, 74.5% in Burg El-Arab soil. While, Nubaria soil recorded only an average 6.1% of soil bound residues. This work is the milestone of a more detailed research framework for a better understanding of the environmental fate and behavior of aldicarb under the Egyptian soil conditions.

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الملخص العربي

مصير وسلوك مبيد الألديكارب تحت ظروف الأراضى المصرية:
أ- ميكانيكيات الإدمصاص/الانطلاق والجزء المرتبط بالأرض

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لزيادة تفهم سلوك المبيدات فى البيئة سواء للمهتمين بمكافحة الآفات أو للمهتمين بدراسة تلوث البيئة بالمبيدات تتضح أهمية دراسة عملية اتزان المبيدات بين الجزء الحر فى المحلول الأرضى وبين الجزء المدمص وكذلك الجزء المرتبط بالطور الصلب للأرض. وقد تم إجراء عدة تجارب معملية لدراسة ميكانيكية عملية ادمصاص مبيد الألديكارب. فى معلق أرض : ماء بنسبة (١:١٠) لعينات سطحية (صفر-٣٠ سم) لخمسة أنواع من الأراضى المصرية والتى جمعت من منطقة ابيس، أبو المطامير، السادات، برج العرب، النوبارية (قرية حسين أبو اليسر). وتم استخدام محلول $0.01M$ $CaCl_2$ كخلفية إلكتروليتية لتفادى التأثير غير المرغوب لعملية التخفيف ومحاكاة القوة الأيونية للمحلول الأرضى.

فقد تم دراسة ديناميكية إدمصاص المبيد وعلاقتها بالزمن Adsorption Kinetics ، وذلك بتعريض الأراضى المدروسة لتركيز إبتدائى من المبيد مقداره ٢٠ مجم/لتر (١٠٠% مادة فعالة) مع الرج لفترات زمنية متزايدة هى: ٠,٠٨ ، ٠,٥ ، ١,٠ ، ٣,٠ ، ٦,٠ ، ١٢ ، ٢٤,٠ ساعة على درجة حرارة ٢٥م. ثم فصل الطور الصلب عن الطور السائل بالطرد المركزى، وتم تقدير التركيز النهائى. ولقد وجد أن متوسط زمن الاتزان لمركب الألديكلارب هو ١,٠ ساعة، وبعد هذا الزمن لم يحدث تغير معنوى فى كمية المبيد المدمص.

كما تم دراسة قدرة الأراضى المدروسة على إدمصاص مبيد الألديكارب من خلال فحص منحنيات الإدمصاص عند درجة حرارة ثابتة (٢٥م) Adsorption Isotherm ، وذلك بتعريضها لسلسلة من التركيزات الإبتدائية للمبيد هى. صفر، ٥، ١٠، ٢٠، ٣٠، ٤٠ مجم/لتر (١٠٠% مادة فعالة). وتم الرج لزمن الإتزان ثم الطرد المركزى، وقد دلت النتائج على أن عملية إدمصاص هذا المبيد على الأراضى المختبرة تتبع معادلة فرويندليخ Freundlich بمعامل ارتباط أكبر من ٠,٩٥ واتضح أن عملية الإدمصاص لهذا المبيد ترتبط بعلاقة وثيقة مع نسبة محتوى الأراضى من المادة العضوية، وكذلك نسبة محتواها من الطين. وتبعا لقيم كل من K, K_d, K_{om} المحسوبة يمكن ترتيب الأراضى المدروسة حسب قدرتها على الاحتفاظ بهذا المبيد كما يلى: أبيس = ابو المطامير > السادات > برج العرب > النوبارية.

وبالإضافة لما سبق فقد تم دراسة قابلية مبيد الألديكارب للتحرر من خلال عملية عكس الإدمصاص Desorption عن طريق خفض تركيز المبيد فى محلول الاتزان مرتين متتاليتين. وقد ابدت الأراضى المدروسة درجات متفاوتة من قدرتها على الإحتفاظ بالمبيد. وأظهرت اراضى ابيس وابو المطامير قدرة أعلى على الإحتفاظ بالمبيد من أراضى السادات وبرج العرب، وهذه كانت أعلى من أرض النوبارية.

وأخيرا تم دراسة التوزيع النسبى الصور التى يتواجد عليها مبيد الألديكارب بعد إدمصاصه على الأراضى المدروسة Fractionation. ودلت النتائج على أن الجزء من الألديكارب المرتبط بالأرض Soil-Bound Residues وغير قابل للتحرر بالمذيبات القطبية أو غير القطبية يمثل ٨٧,٠% من الكمية المدمصة فى أراضى ابيس وابو المطامير والسادات، ويمثل ٧٤,٥% فى أرض برج العرب، بينما يمثل ٦,١% فقط فى أرض النوبارية.

Environmental Assessment of Soil and Plants Pollution Caused by Industrial Activities at Abou-Zaabal Area in Egypt

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ABSTRACT

This study aims to evaluate the environmental impacts of dust and fumes of the superphosphate fertilizer factory at Abou-Zaabal area El-Kaluobia governorate on soil and plants of Ezbet-Shokry, which is located at the south side of the factory. Therefore, surface and subsurface soil samples as well as plant samples were collected from twelve sites at different distances from the factory. Each plant sample was divided into two subsamples, one was washed with distilled water and the other was left unwashed

Obtained data of available phosphorus, Fe, Mn, Cu, Zn, Pb, Ni and Cr as well as soluble S, Ca and Mg in surface and subsurface soil sample show a negative pronounced effect for the distance faraway the factory on their accumulation in the soil However, no homogeneous distribution for these elements between the surface and subsurface soil layers was encountered, which may be due to the variety of grown plant and the irrigation status.

Pronounced difference in phosphorous, K, S, Fe, Mn, Zn, Cu, Pb, Ni, Cr and B total contents between the washed and unwashed plant samples were observed Concentration of surface and both phosphorus and K was superior in the cabbage and colocassia plant leaves, respectively, as compared with their accumulation in the other concerned plants.

Therefore, the damage or the burning spots on the leaves of these plants may be attributed to the sulfur oxide fumes emitting from the factory. No significant differences in the concentration of heavy metals with plant variety were observed. However, concentration of these heavy metals in plant tissue did not reach phytotoxic levels.

Keywords: supperphosphate, fertilizers, contamination, phosphours, sulfur trace

INTRODUCTION

Pollution word, which means much for life on our planet, has been arisen as an important issue and come out to world almost interest over the last 30 years being correlated with the accelerating expansion of urbanization and industrialization. Most air pollution has arisen from the burning of coal and other fossil fuels and from smelting of iron and nonferrous metals. In general, elements which from volatile compounds, or are present at a lower particle radius, may be readily released into the atmosphere from the burning of coal and other industrial pollution. At a time when environmental quality and food production are of major concern to man, a better understanding of the behavior of trace elements in the air-soil-plant system seems to be particularly significant (Kabata-Pendias & Pendias, 1992).

Several authors have shown a relationship between atmospheric element deposition and elevated element concentration in plants and top soils, especially in cities and in the vicinity of emitting factories (Andersen et al., 1978; Voutsa et al., 1996; El-Desoky and Ghallab, 2000). Atmospheric elements are deposited on plant surfaces by rain and dust. Airborne submicronic particles are also filtered out on plant surfaces, constituting a substantial, but unknown contribution to the atmospheric supply. Indirect effects of air pollutants through the soil are also of great importance, because of the large-scale sustained exposure of soil to both wet and dry deposition of trace elements.

Concentration of Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in the top soil of area located south and southeast of Cairo were reported to be affected by the metal content of air-borne dust, which is influenced by industrial metal emissions in other area of the city. Abou-Qir fertilizer and chemical industrial company are emitting significant quantities of gases into the atmosphere, causing considerable air pollution problems (El-Desoky and Ghallab, 2000).

Some industrial factories such as superphosphate fertilizers factory, which is located at Abou Zaabal area, El-Kaluobia governorate, sometimes cause some pollution problems at Ezbet Shokry area at the south side of the factory due to airborne dusts and smokes. Some problems are related to soil contamination with heavy metals, plant damage from industrial dusts and airfumes that may also contain some heavy metals. Therefore, the present study aims to evaluate soil and plants at the aforementioned area with regard to some elements and heavy metals pollution.

MATERIALS AND METHODS

This study was carried out at Ezbet Shokry area, which is located at the south side of the superphosphate fertilizers factory at Abou Zaabal region El-Kaluobia governorate. Soil and plant samples were collected from 12 sites distributed at four different distances (100, 500, 1500 and 3000m) at the south direction faraway from the factory. Two soil samples were taken from each site, one at 0-10 cm depth and other at 10-30 cm depth. Plant samples were also collected at the same time from cabbage or strawberry or colocasia plants that were grown on the soil at each site.

The soil samples were air dried, crushed, passed through 2 mm sieve and kept for analysis. Some chemical and physical characteristics of a soil sample presented the studied area and some heavy metals content in the irrigation water sample are presented in Tables (1 and 2), respectively. Soluble cations and anions as well as electrical conductivity (EC) in the soil samples were determined in the extraction of soil paste. Available P, Fe, Mn, Zn, Cu, Pb, Ni and Cr in the soil samples were extracted with

NH_4HCO_3 -DTPA (AB-DTPA) according to Soltanpour et al., (1985). On the other hand, each plant sample was divided into two parts, one was washed with distilled water and the other was left without washing. All plant samples were oven dried at 70 °C, ground and digested by HNO_3-$HClO_4$ mixture according to Perkin-Elmer corporation, 1994.

The heavy metals Fe, Mn, Zn, Cu, Pb, Ni and Cr in the digestion solutions of plant samples, AB-DTPA extractable solutions of soil samples and their content in the irrigation water used were determined using an atomic absorption spectrophotometer (Perkin Elmer 3300). However, phosphorus and S were determined in both plant and soil samples using inductively coupled plasma spectrophotometer (ICP).

Table (1) Some characteristics of the studied soil.

Soil properties		Values
Organic matter (O.M)	%	2.01
$CaCO_3$	%	1.05
Particle size distribution		
Clay	%	8.0
Silt	%	24.5
Sand	%	67.5
Texture class		Sandy loam

Table (2) Some heavy metals content in the irrigation water.

Element	Fe	Mn	Zn	Cu	Cd	Ni	Pb	Cr	B	Co
(mgL^{-1})	0.005	0.006	0 007	0.004	n.d.	0.035	0.223	0.111	0.477	0.051

RESULTS AND DISCUSSION

1- Soil salinity and soluble cations and anions:

Obtained data in Table (3) show the electrical conductivity (EC) and soluble cations and anions of the soil samples taken from Ezbet Shokry area, which is located at the south side of the superphosphate factory at Abou Zaabal region. The EC values of the surface soil sample of the soil cultivated with strawberry, cabbage and colocasia ranged from 2.85 to 8.9, 1 05 to 8.9 and 4.9 to 11.5 dSm^{-1} respectively. However, its values of the subsurface soil samples of strawberry, cabbage and colocasia ranged between 2.27-5.00, 1.1-3.95 and 1.95-6.95 dSm^{-1}, respectively. Thus, the surface soil samples generally contained higher salinity than subsurface ones. In most case, salinity in the soil samples slightly increased southward

with increasing distance from the factory until 1500m. Levels of soluble calcium and magnesium were higher than those of sodium and potassium especially in the surface soil samples than in the subsurface. Also, as shown in Table (3) concentration of sulfate, in most cases, was more or less three times the concentration of chloride. Therefore, dominance of calcium and magnesium, to a great extent, as sulfate salts in the soils at the south side of the superphosphate factory confirms that these soils are contaminated by the phosphate dusts that contain high levels of calcium and magnesium, as well as the sulfur oxides Fumes (El-Desoky and Ghallab, 2000).

Table (3) Electrical conductivity and soluble cations and anions in the studied soil samples.

Distance from the Factory (m)	Plant Type	Depth (cm)	EC (dSm^{-1})	Cations (meq $100g^{-1}$ soil)				Anions (meq $100g^{-1}$ soil)			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
100	Strawberry	0-10	2.85	0.48	0.10	0.12	0.02	-	0.04	0.08	0.60
		10-30	5.00	0.97	0.25	0.31	0.03	-	0.05	0.52	0.99
	Cabbage	0-10	1.05	0.16	0.06	0.12	0.01	-	0.05	0.10	0.19
		10-30	1.10	0.16	0.12	0.05	0.01	-	0.06	0.05	0.23
	Colocasia	0-10	4.90	0.58	0.38	0.44	0.07	-	0.08	0.44	0.94
		10-30	2.60	0.32	0.17	0.23	0.04	-	0.05	0.25	0.47
500	Strawberry	0-10	5.40	1.24	0.46	0.30	0.07	-	0.07	0.36	1.63
		10-30	2.78	0.42	0.28	0.29	0.01	-	0.07	0.25	0.68
	Cabbage	0-10	2.40	0.37	0.18	0.24	0.04	-	0.07	0.20	0.54
		10-30	2.00	0.33	0.13	0.18	0.03	-	0.06	0.14	0.47
	Colocasia	0-10	6.80	1.07	0.67	0.59	0.08	-	0.10	0.74	1.57
		10-30	4.10	0.63	0.41	0.34	0.06	-	0.06	0.44	0.93
1500	Strawberry	0-10	8.90	1.88	0.84	0.61	0.06	-	0.06	0.91	2.41
		10-30	3.50	0.48	0.31	0.33	0.05	-	0.05	0.30	0.82
	Cabbage	0-10	3.04	0.29	0.11	0.50	0.02	-	0.08	0.52	0.32
		10-30	3.95	0.44	0.32	0.69	0.03	-	0.07	0.84	0.57
	Colocasia	0-10	11.5	1.11	0.59	2.28	0.04	-	0.08	1.96	1.98
		10-30	6.95	0.76	0.54	0.99	0.09	-	0.06	0.99	1.33
3000	Strawberry	0-10	5.60	0.80	0.51	0.53	0.04	-	0.07	0.59	1.22
		10-30	2.27	0.31	0.24	0.19	0.02	-	0.07	0.14	0.56
	Cabbage	0-10	8.90	1.11	0.83	1.16	0.05	-	0.07	1.29	1.77
		10-30	2.45	0.38	0.16	0.42	0.02	-	0.09	0.29	0.62
	Colocasia	0-10	7.35	0.65	0.54	0.72	0.12	-	0.06	0.67	1.29
		10-30	1.95	0.23	0.18	0.17	0.02	-	0.06	0.15	0.38

2- Available content of phosphorus and metals in soil.

Available phosphorus as shown in Table (4) ranged from 3.21 to 22.3 and from 9.47 to 27.1 ppm in the surface and subsurface soil samples, respectively. No clear trend for phosphorus distribution between surface and subsurface soil layers was encountered. This may be due to the irrigation status, plant type and species, sampling site and growing period of the plant (Voutsa et al., 1996). However, summation of P in both surface and subsurface soil samples, to some extent, decreased far from the factory

towards the south direction. This verifies that superphosphate dust resulting from the factory are the main contamination source for the studied area.

Obtained data in Table (4) also show the distribution of available Fe, Mn, Zn and Cu in the surface and subsurface soil layers at Ezbet Shokry area. Concentration levels of Fe in surface soil layers cultivated with cabbage, strawberry and colocasia ranged from 2.27 to 5.24 , 3.83 to 11.2 and 2.43 to 4.84 ppm, respectively. Whereas, its concentration in the subsurface layers of the same plants lied between 1.3 – 9.06, 2.01 to 4.29, and 3.00 to 5.22 ppm, respectively. In most cases, its available content was higher than that in the subsurface layers. But, in general, its concentration decreased with distance far from the factory. These results are in agreement with those obtained by Abd El-Mottaleb et al. (1993) and El-Desoky & Ghallab (2000).

AB-DTPA-extractable Cu, Zn, and Mn in the surface and subsurface soil samples as shown in Table (4) have, to a great extent, the same behavior of Fe as above-mentioned in the soil layers at all distances far from the factory. However, the available content of Cu, Zn and Mn were more or less twice, the same and half the concentration of Fe, respectively. Undoubtedly, the difference in the concentration level of Fe, Mn, Zn and Cu in both surface and subsurface soil layers at every distance far from the factory may be due to the plant type, growth period, element uptake and the irrigation status (Voutsa et al., 1996).

Table (4): Available phosphorus, Fe, Mn, Zn and Cu in surface and subsurface soil samples.

Distance from the Factory (m)	Plant type	(mg kg^{-1} soil)									
		P		Fe		Mn		Zn		Cu	
		Sur.	Subs.	Sur.	Subs.	Sur.	Subs.	Sur.	Subs.	Sur	Subs.
100	Cabbage	9.41	16.0	5.24	9.06	1.93	3.07	5.10	9.50	10.6	16.8
	Strawberry	18.2	27.1	3.97	4.29	5.71	1.35	3.77	4.46	8.26	7.64
	Colocasia	16.8	18.2	4.84	5.22	7.62	8.00	5.94	6.50	12.6	13.8
500	Cabbage	16.8	11.5	4.60	3.50	2.12	1.90	3.84	2.88	10.2	9.6
	Strawberry	10.4	14.4	11.2	3.42	2.70	7..19	11.1	3.46	21.8	8.38
	Colocasia	13.6	10.2	4.20	3.50	6.50	4.90	4.72	4.00	10.4	9.52
1500	Cabbage	22.3	8.83	2.27	2.00	1.80	1.91	2.15	1.94	9.08	9.28
	Strawberry	16.6	21.9	4.01	2.01	1.88	3.05	3.56	2.04	10.9	7.97
	Colocasia	3.21	4.86	2.49	3.00	6.20	3.73	2.43	2.97	9.85	9.32
3000	Cabbage	15.9	9.91	2.81	1.30	3.85	1.06	2.95	1.27	12.9	5.70
	Strawberry	12.1	9.47	3.83	2.69	1.94	2.61	4.13	2.60	14.6	9.97
	Colocasia	12.7	9.68	2.43	3.32	1.44	4.93	2.25	3.37	8.45	8.43

Sur. = Surface layer (0-10 cm)
Subs. = Subsurface layer (10-30 cm)

Available content of Pb, Ni and Cr in the surface and subsurface soil sample of the studied area are presented in Table (5). A negative

relationship between the concentration of both Pb and Cr in the two soil layers and the distance faraway from the superphosphate factory in the south direction was encountered. However, no clear trend for distribution of Pb in the soil area cultivated with strawberry and for Ni at all soil layers was observed. Obtained data also showed that the concentration gradient of Pb, Ni and Cr in the soil layers was as follows Pb > Ni > Cr. In spite of that the available soil content of the studied metals as shown in Table (5) is in nonmal range, as it was indicated by Kabata-Pendias and Pendias (1992). Lead may reach the surface soil from superphosphate factory chimnies carrying by wind, as white particles resulting from phosphate rock grinding, during the manifacture of superphosphate fertilizers (El-Sherif, 1979 and El-Desoky and Ghallab, 2000). Ni recently has become a serious pollutant that is released in the emissions from metal processing operations. The application of certain phosphate fertilizers also may be important sources of Ni. Anthropogenic sources of Ni, from industrial activity in particular, have resulted in a significant increase in the Ni content of soils (Kabata-Pendias and Pendias, 1992).

Table (5) Available lead, Ni and Cr in surface and subsurface soil samples.

Distance from the factory (m)	Plant type	(mg kg^{-1} soil)					
		Pb		Ni		Cr	
		Sur.	Subs.	Sur.	Subs.	Sur.	Subs.
100	Cabbage	2.12	3.68	0.358	1.38	0.206	0.200
	Strawberry	1.95	1.79	0.464	0.290	0.434	0.294
	Colocasia	2.73	3.00	0.582	0.49	0.473	0.31
500	Cabbage	1.86	3.20	0.392	0.982	0.182	0.20
	Strawberry	4.36	1.44	1.54	0.502	0.170	0.246
	Colocasia	1.86	2.40	0.482	0.420	0.40	0.29
1500	Cabbage	1.66	2.52	0.384	0.448	0.156	0.190
	Strawberry	1.91	1.47	0.350	0.166	0.222	0.162
	Colocasia	1.47	2.03	0.42	0.50	0.256	0.274
3000	Cabbage	2.07	1.30	0.380	0.242	0.252	0.156
	Strawberry	2.27	1.85	0.510	0.356	0.286	0.204
	Colocasia	1.69	1.72	0.300	0.430	0.22	0.238

Sur. = Surface layer (0-10 cm)
Subs. = Subsurface layer (10-30 cm)

3- Phosphorus, potassium and sulfur in plant:

Data presented in Table (6) show the contents of P, K and S in washed and unwashed leaves samples of cabbage, strawberry and colocasia plants, taken from the studied area. Concentration levels of P, K and S in all unwashed plant samples were slightly higher than those obtained in the washed ones. A negative pronounced effect for the distance far from the factory in the south direction on the total content of P, K and S of the

different grown plant samples , to a great extent, was encountered. This may be due to superphosphate fertilizers factory uses phosphate rock and sulfuric acid to produce superphosphate. Dusts resulted from the factory during superphosphate production contain phosphate particulates as well as other mineral impurities such as feldspars and micas that contain potassium. These dusts are expected to raise levels of both P and K of the washed and unwashed samples. Also, sulfur oxide fumes that are emitted from the factory chimnies during sulfuric acid formation from elemental sulfur can be absorbed by plant leaves or burning them when their concentration on leaves' surface are to be high (El-Desoky and Ghallab, 2000).

It is noticed that concentration of K in the leaves tissue of all studied plants was two to nine times higher than concentration of P. On the other hand, sulfur concentration was Five to six Folds P content in cabbage, but more or less the same values in both strawberry and colocasia. Both P and K concentration in colocasia plant leaves at all the different distances faraway from the factory was, in general, twice and two to three folds, respectively, their versus concentrations in strawberry and cabbage plants. This may be attributed to the intensive irrigation applied in colocasia than other crops, element uptake and plant species. On the other hand, sulfur content in the studied cabbage was two to seven and two to four times higher than that in the strawberry and colocasia, respectively. These results are higher than those obtained by (El-Desoky and Ghallab, 2000) and may confirm that sulfur oxide fumes emitted from the superphosphate factory are the responsible about the deterioration effect which was observed on the studied plant leaves in the field especially cabbage.

4- Some heavy metals in plant:

Iron, Mn, Zn and Cu concentrations determined in the plants taken from the studied area are presented in Table (7). The unwashed plant samples, in general, had higher concentrations of the concerned elements than those in the washed ones.

Table (6) Total content of phosphorus, K and S in plant.

Plant type	Distance from the factory (m)	(g /100g plant)					
		P		K		S	
		W	UW	W	UW	W	UW
Cabbage	100	0.35a	0.43a	1.55a	2.06a	0.90b	1.05b
	500	0.30b	0.34b	1.40a	1.90b	1.00ab	1.20b
	1500	0.20d	0.26c	1.33a	1.64c	1.16a	1.61a
	3000	0.25c	0.26c	1.64a	2.19a	1.11ab	1.24b
	L.S.D	0.037	0.040	NS	0.143	0.226	0.270
Strawberry	100	0.39a	0.41a	0.94c	1.02a	0.34a	0.33a
	500	0.36a	0.37b	1.17b	1.17a	0.14c	0.18b
	1500	0.19c	0.30c	0.70d	1.33a	0.16bc	0.23b
	3000	0.26b	0.27c	1.41a	1.33a	0.22b	0.23b
	L.S.D	0.033	0.034	0.121	NS	0.073	0.052
Colocasia	100	0.67a	0.69a	3.28b	3.68a	0.45a	0.50a
	500	0.54b	0.63b	3.60a	3.68a	0.33b	0.42ab
	1500	0.37c	0.40c	2.58c	3.21b	0.32b	0.37b
	3000	0.37c	0.40c	3.05b	3.05b	0.32b	0.35b
	L.S.D	0.038	0.040	0.295	0.236	0.061	0.085

W = Washed UW = Unwashed
LSD: at 5% level. NS: Not significant differences

It is well known that a fraction of trace elements absorbed by leaves may be leached by washing, and that this fraction is largely variable between elements, depending on their function or metabolic deposit on leaf surfaces. For example, Pb is mainly a superficial deposit on leaf surfaces, whereas Cu, Zn and Cd show greater leaf penetration (Kabata-Pendias & Pendias, 1992; Voutsa at al., 1996). No systematic trend for the distribution of Fe, Mn, Zn and Cu in all plant samples at the different distances far from the factory was observed, as shown from the statistical analysis in Table (7).

Concentrations of Fe , Mn and Zn in every plant studied were, to a great extent, the same values However, concentration of Cu was, in general, two to ten times lower than the concentration of aforementioned micronutrients in plant tissue. This may be due to mobilization of these elements to the leaves after uptake from the soil. It is known that Cu has low mobility relative to other elements in plants, and a strong capability of roots tissues to hold Cu against the transport to shoots under conditions of both Cu deficiency or excess has been reported (Kabata-Pendias & Pendias, 1992). By contrast, Mn is known to be taken up and translocated within plants rapidly, preferentially to meristematic tissues, so it is mostly concentrated in young expanding tissue (Vousta et al., 1996).

Contents of Pb, Ni and Cr in the investigated plant samples, taken from Ezbet Shokry area at Abou Zaabal region, are presented in Table (8). Concentration levels of Pb in the unwashed plant samples (20.6 to 50.8 ppm) were quite high, compared with the washed ones (6.00 to 35.6 ppm). Deposition of airborne suspended particulates emitted from the factory may cause these differences as well as Pb is mainly a superficial deposition leaf surfaces.

Concentration levels of Ni and Cr in the unwashed concerned plant samples varied between 6.8-68.1 and 10.2-156.8 ppm, respectively. However, their levels in the washed plant samples ranged from 2.00-27.1 and 8.6-70.0 ppm, respectively. It is noticed that no clear trend for the distribution of Pb, Ni and Cr in the assignee plant samples as the distance faraway from the factory. Also, the quite differences in content levels of the concerned heavy metals in cabbage, strawberry and colocasia plant leaves indicate that the plant composition only reflects the composition of the soil or the atmosphere, but it is a function of compound-selective processes, such as uptake, translocation and enzymatic actions that take place on the root and foliar surfaces, or in plant cells. These results are in agreement with those obtained by Eissa and El-Kassas, (1999) and El-Desoky and Ghallab (2000).

It is evident that the concentration levels of heavy metals did not reach the toxic levels in plant tissues, but they may be higher than those in plants grown in uncontaminated agricultural soils. This declears that plant damage in the studied area is not a matter of toxic concentration of heavy metals in plant tissue, but instead it seems to be the direct mechanical of dust particulates that continuously cover over ground plant organs as well as precipitation of sulfur oxide fumes on the plant leaves. Therefore, cultivation of plants such as grasses and clover in Ezbet Shokry area are not suitable for grazing of feeding domestic animals. Also, the environmental pollution in this area already have hazard effects on animal and Human health. Therefore, it is important to issue laws and limitations for this factory to prevent its pollution wastes in this area.

Table (7) Total content of Fe, Mn, Zn and Cu in plant.

Plant type	Distance from the Factory (m)	(mg kg⁻¹ soil)							
		Fe		Mn		Zn		Cu	
		W	UW	W	UW	W	UW	W	UW
Cabbage	100	22.5a	33.6a	24.5a	37.9a	23.6a	34.6a	3.30a	4.00ab
	500	21.0bc	30.0b	23.0a	30.6c	21.2bc	29.8b	3.00ab	3.60b
	1500	19.9c	24.6c	22.2ab	42.1b	20.0c	29.4b	3.50a	4.30a
	3000	21.6ab	24.9c	19.4b	30.1c	21.58b	22.0c	2.50b	2.50c
	L.S.D	1.465	1.883	3.020	2.413	1.400	2.171	0.679	0.617
Strawberry	100	35.4c	44.8a	44.6a	50.0a	34.1c	48.0a	24.9a	35.6a
	500	36.5c	46.5a	34.88b	39.9c	39.3b	45.4b	8.00c	9.90c
	1500	45.0a	44.7a	36.6b	43.1b	43.9a	46.1ab	9.00bc	12.1b
	3000	40.1b	45.0a	26.6c	44.7b	37.5b	45.5b	10.0b	10.9bc
	L.S.D	2.141	NS	2.235	2.176	2.10	2.141	1.073	1.452
Colocasia	100	24.1a	54.2a	40.5c	77.8c	43.2a	53.3a	17.4a	22.7a
	500	40.8a	43.2b	128.7a	135.3b	40.0b	45.5b	11.9b	22.9a
	1500	28.2c	40.8c	72.5b	279.3a	26.6d	34.1d	9.70c	10.8b
	3000	32.4b	37.9d	37.2c	52.8d	31.8c	37.4c	7.00d	8.90c
	L.S.D	1.533	1.165	3.427	3.018	2.526	3.138	1.141	1.231

W = Washed UW = Unwashed LSD: at 5% level NS: Not significant differences.

Table (8) Total content of Pb, Ni and Cr in plant

Plant type	*Distance from the Factory (m)*	(g/100 g plant)					
		Pb		Ni		Cr	
		W	UW	W	UW	W	UW
Cabbage	100	6.00c	23.2c	8.80a	10.0b	15.8a	20.8b
	500	10.0b	20.6d	5.00b	9.4b	14.1b	18.2c
	1500	17.4a	27.8b	2.00d	54.7a	15.5a	73.1a
	3000	16.9a	30.7a	4.00c	7.5c	12.4c	13.8d
	L.S.D	0.679	1.321	0.821	0.893	0.927	1.231
Strawberry	100	23.8c	37.4c	15.0a	30.0b	39.6a	94.3a
	500	30.6b	42.4b	5.10c	6.8d	9.8d	10.2d
	1500	35.4a	42.8b	9.80b	10.21c	19.8b	21.1c
	3000	35.6a	50.8a	3.70d	36.8a	14.3c	73.4b
	L.S.D	1.779	1.564	0.869	1.134	1.440	1.848
Colocasia	100	31.5a	33.8b	27.1a	68.1a	70.0a	156.8a
	500	19.8c	31.1c	9.40b	11.1c	16.8b	38.9b
	1500	31.3a	40.3a	6.70c	7.50d	11.9c	14.3d
	3000	22.2b	24.8d	2.60d	14.8b	8.60d	20.7c
	L.S.D	1.847	2.169	0.679	0.692	0.955	2.310

W = Washed UW = Unwashed LSD: at 5% level NS: Not significant differences

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الملخص العربي

التقييم البيئي لتلوث التربة والنبات الناتج عن النشاط الصناعي بمنطقة أبو زعبل- مصر

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يهدف هذا البحث إلى تقييم الآثار البيئية للأتربة والأدخنة الناتجة عن مصنع الأسمدة الفوسفاتية بأبي زعبل - بالقليوبية على الأرض وبعض النباتات النامية في عزبة شكري المتاخمة للجانب الجنوبي للمصنع. وفى هذا الشأن أخذت عينات تربة سطحيه وتحت سطحيه وكذلك عينات نبات من أثنى عشر موقعا على مسافات متباعدة من المصنع. وقد قسمت عينات النبات إلى قسمين: الأول تم غسيله بالماء المقطر ، والآخر ترك بدون غسيل.

أوضحت النتائج المتحصل عليها أن الصورة الميسرة من كل من الفوسفور ، الحديد، النحاس، الزنك، الرصاص، النيكل والكروميوم بالإضافة إلى الصورة الذائبة من الكبريت، الكالسيوم والماغنسيوم قد قل تركيزها لحد ما في التربة والنبات بزيادة البعد عن المصنع في اتجاه الجنوب. إلا أنه لم يكن هناك اتجاه واضح لتراكم تلك العناصر في كل من طبقتي التربة، والذي قد يرجع لنوع النبات النامي وحاله الري.

أظهرت نتائج العناصر تحت الدراسة في أوراق النبات انه يوجد فروق واضحة بين تركيز كل من الفوسفور ، البوتاسيوم، الكبريت، الحديد، الزنك، النحاس، الرصاص، النيكل والكروميوم بالإضافة للبورون في أوراق النباتات الغير مغسولة عنها في النباتات المغسولة بالماء المقطر. وقد أظهرت النتائج أيضا أن أكثر هذه العناصر تركيزا ووضحا في النباتات الغير مغسولة عنها في المغسولة كان الكبريت في أوراق الكرنب، الفوسفور في القلقاس مقارنه بباقي العناصر. ولذلك فالحروق والتلفيات التي وجدت بأوراق النباتات النامية قد يرجع إلى تأثير الأكاسيد الكبريتية المنبعثة من مداخن المصنع. و أوضحت النتائج أيضا عدم وجود فروق معنوية في تركيز العناصر الثقيلة بين النباتات المختلفة مع العلم بأن تركيزها في النباتات لم يصل لحد السمية.

Environmental Assessment of Drainage Water in Nile Delta for Sustainable Agricultural Development: I- Salinity Hazard

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ABSTRACT

This study were carried out to assess the drainage water quality for reusing irrigation. Samples of drainage water (each represent drain or Canal) were collected monthly during the period from June, 1999 to May, 2000 for Nile Delta region. The results indicated that:

- In Eastern Delta, a 45% of the total collected samples of Bahr El Baqr area have a total soluble salts less than 2000 mg/l and were classified as "slight to moderate" grade, while 55% more than 2000 mg/l and were classified as "severe" for irrigation. Meanwhile, at Bahr Hadus areas are 92.3% and 7.7% less and more than 2000 mg/l, respectively. The adj SAR values are classified as "slight to moderate" and "severe" grades. The calculated pHc of all samples is less than 8.4, the soluble calcium from drain water tends to precipitate in soil irrigated with such water.
- No changes in water quality due to salinity in irrigation canals before and after mixing with drainage water officially, they are ranged from 242 to 597 mg/l, which are considered none saline. Whereas, at Dafan and El-Salam canals have moderately saline water. They reached 1460 and 988 mg/l, respectively, which classified as "slight to moderate".
- In Middle Delta, a 64.0% of the total collected samples have a total soluble salts less than 2000 mg/l and classified as "slight to moderate" grade while 3 6.0% more than 2000 mg/l and classified as "severe" for irrigation. The adj. SAR values are classified as "slight to moderate" and "severe" grades for irrigation. The calculated pHc of all samples is less than 8.4, the soluble calcium from drain water tends to precipate in soil irrigated with such water.
- No changes in water quality due to salinity in irrigation canals before and after mixing with drainage water officially, they are ranged from 432 to 599 gm/l, which is consider none.. Whereas, Bahr Tira canal water is moderately saline after with El-Gharbia drain, it reached 1043 mg/l.
- In Western Delta, a 69.6% of the total collected samples have a total soluble salts less than 2000 mg/l and classified as "slight to moderate" grade for irrigation while 30.4% more than 2000 mg/l and classified as "severe". The adj. SAR values are classified as "slight to moderate" and "severe" grades, respectively. The calculated pHc of all samples is less than 8.4, the soluble calcium from drain water tends to precipitate in soil irrigated with such water.
- No changes in water quality due to salinity in irrigation canals before and after mixing with drainage water officially, they are ranged from 279 to 492 gm/i, which is consider none saline. Whereas, El-Nubaria canal has changed its quality and consider "slight to moderate" grade. It ranged from 844 to 1532 mg/l after mixing with drain water namely; El-floustan (km 29), No.1 (km 54), No.3 (km 55) and El-Omoum at Maruit (km 86).

Keywords: Environment, drainage, irrigation, quality, salinity.

INTRODUCTION

Recharge of agricultural drainage water into the irrigation network is beneficial from the point of view of conserving water and increasing the efficiency of water use. In Egypt 7.2 billion cubic meters are used for irrigation purposes every year by blending with canal water. However, some problems might take place due to extensive use of drainage water. Soil salinity and alkalinity may affect the contents of drainage water. The drainage system in Nile Delta is rather extensive and serves 4.7 million feddans of total 7.4 million feddans of agricultural land in Egypt. The total length of the main drains in Nile Delta is about 18260 km (Amer, 1996). The suitability of water for irrigation is depend on the climatic condition, physical and chemical properties of soil, salts tolerances of the crop grown and management practices (Pescod, 1992).

Many schemes of classification for irrigation water have been proposed. Ayers and Westcot (1985) classified irrigation water into three groups based on salinity, sodicity, toxicity, and miscellaneous hazards. These guidelines help to identify potential crop production problem associated with the use of conventional water sources. Hassanien et al. (1993) found that El-Wadi El-Sharqi canal after blending with sewage and drainage water, and along Bahr El-Baqr drain, at El-Salhia and Sahl El-Hessania, water are considered low quality and cause increasing salinity problems. In all locations Na^+ represents the dominate cation followed by Mg^{++} then Ca^{++} and K^+ is the lowest one, $HC0_3$ is the dominant anions followed by Cl and S04. El-Sokary and Sharaf (1996) found that irrigation water mixed with agriculture drainage water with either domestic or industrial effluents or both have salinity build up toxicity hazards.

The ultimate goal of this study is to obtain accurate information related to the quality of drainage water at strategic location along the main drains in Nile Delta where significant changes of salinity hazards due to the addition to or withdrawal from the drain.

MATERIALS AND METHODS

To assess the drainage water quality for reusing it in irrigation, samples of drainage water (each represent drain or canal) were collected monthly during the period from June, 1999 to May, 2000 for Nile Delta. The samples were analyzed immediately for pH, EC, Soluble cations and anions according to the methods described by Jackson (1973).

Three main parts of Nile Delta drains were divided the region to East, Middle and west. These are:

1- Eastern Delta drains:

Code No.	Drain name	Code No.	Drain name
E1	El-Qalubia	E25	El-Wadi El-Sharqi canal "after" mixing
E2	Belbies	E26	Abu El-Akhder canal "before"
E3	Bahr El-Baqr inlet	E27	Abu El-Akhder canal"after"
E4	Blad El-Ayed	E28	El-Salam at Sahret B. El-Baqr km 70
E5	El-Ann	E29	El-Serw Al-Alaa
E6	El-Saada	E30	Farskur
E7	Qahbuna	E31	El-Serw Al-Asfal
E8	Bahr El-Baqr 1	E32	El-Mataria
E9	Bahr El-Baqr 2	E33	Omoum El-Behira Al-Asfal
E10	Ganub Port Said	E34	Omoum El-Behira Al-Alaa
E11	Ganub El-Hessania	E35	El-Fanan
E12	Bahr El-Baqr outlet	E36	El-Qasabi
E13	Shamal Ismalia	E37	Bahr Facous
E14	El-Mahsama	E38	Saft El-Qebli
E15	El-Manief	E39	Zarfodaki
E16	El-Wadi	E40	El-Nizam
E17	Gabal Mariem	E41	El-Senblawin
E18	El-Malaria 1.	E42	Bahr Hadus "outlet"
E19	El-Malaria 2.	E43	Nile at Damyiata "before"
E20	El-Ganien El-Bahri	E44	Nile at Damyiata "after"
E21	El-Ganien El-Qebli	E45	Hanut canal "before"
E22	Genifa	E46	Hanut canal "after"
E23	Shandura	E47	Dafan canal "before"
E24	El-Wadi El-Sharqi canal "before" mixing	E48	Dafan canal "after"

2- Middle Delta drains:

Code No.	Drain name	Code No.	Drain name
M1	El-Sagaiya	M20	El-Mandura
M2	Samatay	M21	Tala
M3	No. 5	M22	Sabal
M4	Ibshan	M23	El-Qamien
M5	El-Gharbia	M24	No. 2
M6	No. 4	M25	Toukh
M7	No. 3	M26	No. 1
M8	No. 5	M27	El-Nasria
M9	El-Brolus	M28	El-Senanya
M10	El-Gharbia "outlet"	M29	Tira canal "before"
M11	Hafir Shehab El-Deen	M30	Tira canal "after"
M12	No. 7 Al-Asfal	M31	Tala canal "before"
M13	No. 8 Al-Asfal	M32	Tala canal "after"
M14	No. 9	M33	Mit Yazid canal "before"
M15	No. 9 "outlet"	M34	Mit Yazid canal "after"
M16	El-Zieni	M35	El-Riah Al-Abass "before"
M17	No. 11	M36	El-Riah Al-Abass "after"
M18	Mohit Zaghloul	M37	Nile at El-Mahllah "before"
M19	Nashart	M38	Nile at El-Mahllah "after"

3- Western Delta drains:

Code No.	Drain name	Code No.	Drain name
W1	Etay El-Baroud	N1	No. 1
W2	Beshara	N2	No. 3
W3	Zarqun	N3	West Nubaria Drain "inlet"
W4	Idko Irrig.	N4	No. 6
W5	El-Dilingat	N5	Koubri Massoud
W6	El-Khandak El-Gharbi	N6	El-Houria El-Nour
W7	El-Khairy	N7	El-Nour
W8	Halq El-Gamal	N8	El-Tahrir
W9	El-Qusor	N9	El-Omoum, Mariut
W10	El-Bousily	N10	West Nubaria "outlet"
W11	Mohit Idko	N11	West Nubaria (km 21)
W12	El-Tabia	N12	El-Boustan
W13	Idko "outlet"	N13	El-Nubaria canal "before" (km 29)
W14	El-Shershra	N14	El-Nubaria canal "after" (km 29)
W15	Abu Humos	N15	El-Nubaria canal "before" (km 86)
W16	Truga	N16	El-Nubaria canal"after" (km 86)
W17	El-Dushudy	N17	Oil waste company
W18	Hares	N18	Navigation canal of El-Nubaria "before"
W19	Abies	N19	Navigation canal of El-Nubaria "after"
W20	El-Qalaa	N20	El-Nubaria canal "before" (km 54)
W21	El-Omoum, Max	N21	El-Nubaria canal "after" (km 54)
W22	Bourg Rashid	N22	El-Nubaria canal "before" (km 55)
W23	El-Khandak El-Sharqi canal "before"	N23	El-Nubaria canal "after" (km 55)
W24	El-Khandak El-Sharqi canal "after"		
W25	El-Hager & Frhash canal "before"		
W26	El-Hager & Frhash canal "after"		
W27	Abu Diab canal "before"		
W28	Abu Diab canal "after"		
W29	El-Mahmudia canal "before"		
W30	El-Mahmudia canal "after"		

3. RESULTS AND DISCUSSIONS

Data presented in Tables (1, 2 and 3) and illustrated in Fig. (1) show the yearly average of the chemical composition of drain water as well as mixed canals of Nile Delta region.

a- Eastern Delta:

*** Bahr El-Baqr area**

The total soluble salts of drain water at Bahr El-Baqr area ranged from 772 to 13870 mg/l, whereas adj. SAR values ranged from 3.7 to 87.81. The calculated pHc of water ranged from 6.6 to 7.45.

From the obtained data, it could be noticed that El-Qalubia and Biad El-Ayied drains have low soluble salts below 1000 mg/l (10.0% of total samples). They are 811 and 772 mg/l, respectively. The total soluble salts of El-Arm, El-Saada, Beibies, Bahr Ei-Baqr 2, ElMahsama, El-Manief, El-Wadi and El-Malaria 1 drains

are ranged from 1022 to 1547 mg/l (35.0% of total samples). It could be concluded that these drains could be reused directly or by mixing with canal water without causing severe problems according to Ayers and Westcot (1985). Their total soluble salts are less than 2000 mg/l.

The total soluble salts of some drains are ranged from 2269 to 2966 mg/l (20% of total samples), namely; Qahbouna, Bahr Ei-Baqrl, Gabai Mariem and Ei-Ganaien El-Behri drains. As well as, Ganub Sahl Port Said, Ganub Sahl El-Hessania, Shamai Ismalia, Malaria 2, El-Ganaien El-Qebli, Genifa and Shandura drains ranged from 3396 to 13870 mg/l (35% of total samples). These drains are considered highly saline for irrigation and classified as "severe" in the degree of restriction in use for irrigation.

The adj. SAR values of drain water of Ei-Qalubia, Belbies, ElAn El-Saada, Bahr El-Baqr 2 and El-Malarial are classified as "slight to moderate" while in Blad El-Ayed drain is "none". The rest of the drains are classified as "severe" because their values are ranged from 9.41 to 87.81 (more than 9) according to Ayers and Westcot (1985). Therefore, hazard is due to soil permeability problem in long run application. The calculated pHc of all drains is less than 8.4, the soluble calcium from drain water tends to precipitate in soil irrigated with such water.

Concerning irrigation canals, which mixed with drain water [Ei-Wadi El-Sharqi (E25) and Abu El-Akhdar (E27)], the total soluble salts of these mixed canal are ranged from 242 to 597 mg/l. Adj. SAR values are ranged from 1.95 to 4.41. Therefore, they are consider "none" in the degree of restriction in use for irrigation and salinity problems does not exist according to Ayers and Westcot (1985). Bahr El- Baqr2 drain is directly used in new reclaimed areas at old Salhia at El-Sharkia governorate. The total soluble salts are 1105 mg/l and adj. SAR value is 8.54. Therefore, this water is classified as "Slight to moderate" in the degree of restriction in use for irrigation and may cause salinity hazard in long run application.

*** Bahr Hadus area:**

The total soluble salts of drains water at Bahr Hadus area ranged from 580 to 2421 mg/l, whereas adj. SAR values ranged from 5.63 to 23.85. The calculated pHc of water ranged from 6.63 to 7.28.

From the obtained data, it could be noticed that El-Serw AlAlaa, Farskur and Saft El-Qebli drains have low soluble salts below 750 mg/l (23.0% of total samples). They are ranged from 580-615 mg /l. The total soluble salts of El-Serw Al-Asfal, Qmoum El-Behira AlAlaa, Zarfudaki, and El-Nizam drains are between 750 and 1000 mg/l (30.8% of total samples). They are ranged from 782 to 1000 mg/l. Some drains, namely; El-Mataria, Omoum El-Behira El-Asfal, Bahr Hadus "outlet", Bahr Facous and El-Senbalwin drains are ranged from 108 1-1847 mg/l (38.5% of total samples). It could be concluded that these drains could be reused directly or by mixing with canal water without causing severe problems according to Ayers and Westcot (1985). Their total soluble salts are less than 2000 mg/l

(92.3% of total samples). Ei-Fanan drain water has total soluble salts equal 2421 mg/l (7.7%) of total samples) and classified as "severe" in the degree of restriction in use for irrigation because of that drain serves heavy clay sodic soils (San El-Hagr area).

The adj. SAR values of drain water of Ei-Serw Al-Aiaa and Saft Ei-Qebli are classified as "none", whereas Farskur and Zarfoudaky drains are classified as "slight to moderate". The rest of drains are in "severe" grade, because they are ranged from 9.66 to 23.85 according to Ayers and Westcot (1985). Therefore, hazard due to soil permeability problem in long run application may occur.

The calculated pHc values of all drains is less than 8.4, the soluble calcium from drain water tends to precipitate in soil irrigation with such water.

Concerning irrigation canals, which mixed with drains water (Nile at El-Serw, Hanut, Dafan and El-Salam canals). The total soluble salts at Nile at El-Serw and Hanut are ranged from 263 to 384 mg/l and adj. SAR are ranged from 1.84 to 3.43. Therefore, they considered "none" in the degree of restriction in use for irrigation and salinity problems doesn't exist, according to Ayers and Westcot (1985). Whereas, El-Salam canals have total soluble salts equal 988 mg/l at Sahret B.Ei-Baqr (km 70) because Ei-Saiam canal is a mixture of Nile water at Farskur (312-384 mg/l), El-Serw Al-Asfal drain water (946 mg/l), is pumped by Ei-Serw Ai-Asfai pump station and Bahr Hadus drain "outlet" (1332 mg/l). Dafan canal Fs ranged from 1240 to 1460 mg/l before and after mixing with Bahr Facous drain (1518 mg/l), this is mainly due to fish farms and high salinity of Bahr Facous drain. They are classified as "slight to moderate" in the degree of restriction in use for irrigation.

b- Middle Delta:

The total soluble salts of drain water ranged from 992 to 6779 mg/l, whereas adj. SAR values ranged from 7.30 to 65.52. The calculated pHc of water ranged from 7.13 to 7.25.

From the obtained data, It could be noticed that Toukh drain has low total soluble salts less than 1000 mg/l (4.0% of total samples), it is equal 992 mg/l. The total soluble salts of Ei-Sagaiya, Samatay, No.5, No. 4, Ei-Gharbia, No. 9 ,No. 11 ,Mohit Zaghiool, Nashart, ElMandura, Tala, Sabal, Ei-Qranin, Ei-Nseria, No.2 and No.1 drains ranged from 1064 to 1788 mg/l (60.0% of total samples). It could be concluded that these drains can be reused in irrigation according to Ayers and Westcot (1985). Their total soluble salts are less than 2000 mg/l.

The total soluble salts of the following drains are ranged from 2291 to 2541 mg/l (8% of total samples), which are namely; Ei-Zieni and No.3 drains. While, Ibshan, Ei-Naseria, Hafir Shehab Ei-Deen, No.7 Ai-Asfal, No 8 Ai-Asfai, Ei-Borious and Ei-Senania drains ranged from 3098 to 6779 gm/l (28% of total samples). These drains are considered highly saline water and are classified as "severe" in the degree of restriction in use for irrigation and may cause salinity problem in long run application.

Table (1): Chemical analysis of water samples (yearly average) from drains and mixed canals of Eastern Delta.

Location	Code No.	EC (dS/m)	T.S.S (mg/L)	(meq/L)								RSC	SAR	Adj. SAR	pHc calculated
				$CO_3^{=}$	CO_3^{-}	Cl^-	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^+	K^+				
	E1	1.27	811	-	5.02	4.22	3.01	2.19	3.64	6.18	0.40	0.54	3.77	8.29	7.20
	E2	1.78	1136	-	4.11	5.43	3.38	2.24	3.63	6.76	0.49	0.78	3.93	7.56	7.20
	E3	1.86	1190	-	4.12	5.11	2.69	1.95	3.58	6.32	4.06	0.63	3.73	7.72	7.20
	E4	1.21	772	-	3.31	1.69	2.30	1.71	2.37	3.14	0.22	0.48	2.19	3.70	7.45
	E5	1.80	1150	-	4.18	4.97	4.39	2.18	3.67	7.72	0.27	0.69	4.46	8.61	7.20
	E6	1.70	1085	-	4.57	4.70	2.69	1.59	3.50	6.97	0.25	0.49	4.38	8.93	7.20
	E7	3.62	2442	-	5.67	23.41	6.07	3.49	7.20	24.27	0.40	2.20	10.28	24.58	6.90
	E8	4.63	2966	-	4.21	34.22	6.09	5.52	10.22	28.56	0.46	2.57	10.14	24.63	6.90
	E9	1.73	1105	-	4.18	5.35	3.44	2.26	3.55	6.89	0.46	1.55	4.05	8.54	7.20
	E10	21.67	13870	-	5.82	192.49	33.69	20.92	44.04	159.30	4.53	10.40	30.97	87.81	6.60
	E11	7.41	4741	-	3.88	57.21	12.08	7.17	19.72	44.85	1.06	5.65	12.38	28.40	6.80
Bahr	E12	5.31	3396	-	4.23	37.36	6.28	5.05	12.06	33.44	0.66	4.03	11.33	28.54	6.90
El-Baqar	E13	12.17	7766	-	4.46	100.23	21.97	19.37	28.82	79.57	1.14	15.73	16.40	44.11	6.70
area	E14	1.94	1242	-	3.54	7.88	3.11	2.41	4.20	8.53	0.22	1.13	4.71	9.41	7.30
	E15	2.42	1547	-	3.64	11.65	9.68	2.85	4.39	17.94	0.19	2.07	9.53	18.83	7.36
	E16	1.60	1022	-	3.53	9.91	3.39	2.81	4.54	9.50	0.31	1.94	4.87	9.93	7.32
	E17	3.55	2269	-	3.10	26.52	5.46	3.83	8.02	23.37	0.42	2.03	9.62	20.40	7.10
	E18	1.74	1112	-	2.94	8.76	6.54	4.34	5.66	8.22	0.27	3.67	3.50	7.47	6.84
	E19	6.37	4077	-	3.13	49.63	11.47	9.51	17.97	36.30	0.63	4.53	9.87	23.81	6.90
	E20	3.63	2321	-	2.40	23.15	11.47	9.31	9.15	18.33	0.50	5.00	5.78	13.32	7.00
	E21	6.78	4341	-	2.91	58.76	9.10	7.06	13.95	49.01	1.03	-	13.95	31.96	6.90
	E22	5.32	3404	-	2.80	44.58	7.84	8.38	11.59	35.02	0.50	-	11.08	25.14	6.90
	E23	9.28	5942	-	2.92	73.88	12.81	12.53	17.36	59.24	0.74	8.18	15.30	34.85	6.90
	E24	0.44	285	-	2.29	1.31	1.05	0.88	1.94	1.79	0.17	0.89	1.45	2.39	7.41
	E25	0.49	313	-	2.63	1.42	1.53	1.29	2.04	2.12	0.19	0.71	1.57	2.48	7.62
	E26	0.36	242	-	2.18	0.97	3.32	1.13	1.62	1.53	0.19	0.51	1.25	1.95	7.41
	E27	0.93	597	-	2.92	4.14	2.06	1.30	3.10	4.87	0.23	3.00	3.18	4.41	7.47
	E28	1.54	988	-	3.18	9.35	2.20	2.04	4.66	7.96	0.24	-	4.31	8.56	7.32

Table (1): Cont.

Location	Code No.	EC (dS/m)	T.S.S (mg/L)	(meq/L) $CO_3^{=}$	CO_3^{-}	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	RSC	SAR *	Adj. SAR	pHc calculated
Bahr Hadus area	E29	0.91	580	-	4.40	3.30	1.51	2.44	2.35	4.20	0.22	0.94	2.76	5.63	7.27
	E30	0.96	615	-	4.27	3.88	1.67	2.39	2.22	4.76	0.46	0.79	3.17	6.72	7.28
	E31	1.48	946	-	4.86	7.56	2.56	2.61	3.65	8.43	0.29	-	4.78	10.54	7.20
	E32	2.89	1847	-	5.57	17.17	6.38	3.67	6.99	17.98	0.47	-	7.83	18.56	6.63
	E33	2.43	1554	-	5.54	14.25	4.67	4.23	5.05	14.84	0.34	-	6.93	14.92	6.87
	E34	1.56	1000	-	4.79	8.11	3.00	2.88	3.46	9.25	0.31	0.74	4.99	10.98	6.72
	E35	3.78	2421	-	6.14	24.11	8.87	6.18	8.29	24.26	0.44	-	9.04	23.85	6.75
	E36	2.13	1365	-	5.46	11.80	4.32	4.17	5.36	11.64	0.30	-	5.45	12.17	6.90
	E37	2.37	1518	-	5.17	11.34	7.54	4.59	5.12	14.09	0.24	-	6.12	13.59	6.98
	E38	0.93	596	-	4.91	2.17	2.34	2.26	2.52	4.34	0.32	0.60	2.63	5.77	7.17
	E39	1.44	921	-	4.70	6.34	3.53	3.05	3.64	7.61	0.27	-	4.13	9.08	6.95
	E40	1.22	782	-	5.29	4.51	2.67	2.62	2.62	6.89	0.31	0.67	4.30	9.66	7.18
	E41	1.69	1061	-	5.33	8.75	3.53	3.47	4.09	9.74'	0.32	-	5.06	11.63	7.04
	E42	2.08	1332	-	5.16	10.86	6.29	3.69	4.82	13.50	0.30	-	5.92	12.81	7.08
	E43	0.49	312	-	3.13	0.79	1.13	-	1.39	1.70	0.19	0.21	1.38	2.51	7.51
	E44	0.60	384	-	3.47	1.43	1.34	1.92	1.51	2.56	0.19	0.47	1.93	3.43	7.85
	E45	0.41	263	-	2.84	0.71	0.69	1.54	1.17	1.35	0.18	0.26	1.16	1.84	7.60
	E46	0.51	324	-	3.16	1.18	0.87	1.70	1.48	1.92	0.19	1.59	1.51	2.68	7.52
	E47	1.94	1240	-	4.62	10.46	4.49	4.24	4.25	10.82	0.26	-	4.43	10.04	7.00
	E48	2.28	1460	-	5.01	12.54	5.53	4.63	4.97	13.20	0.28	-	5.23	12.25	7.05

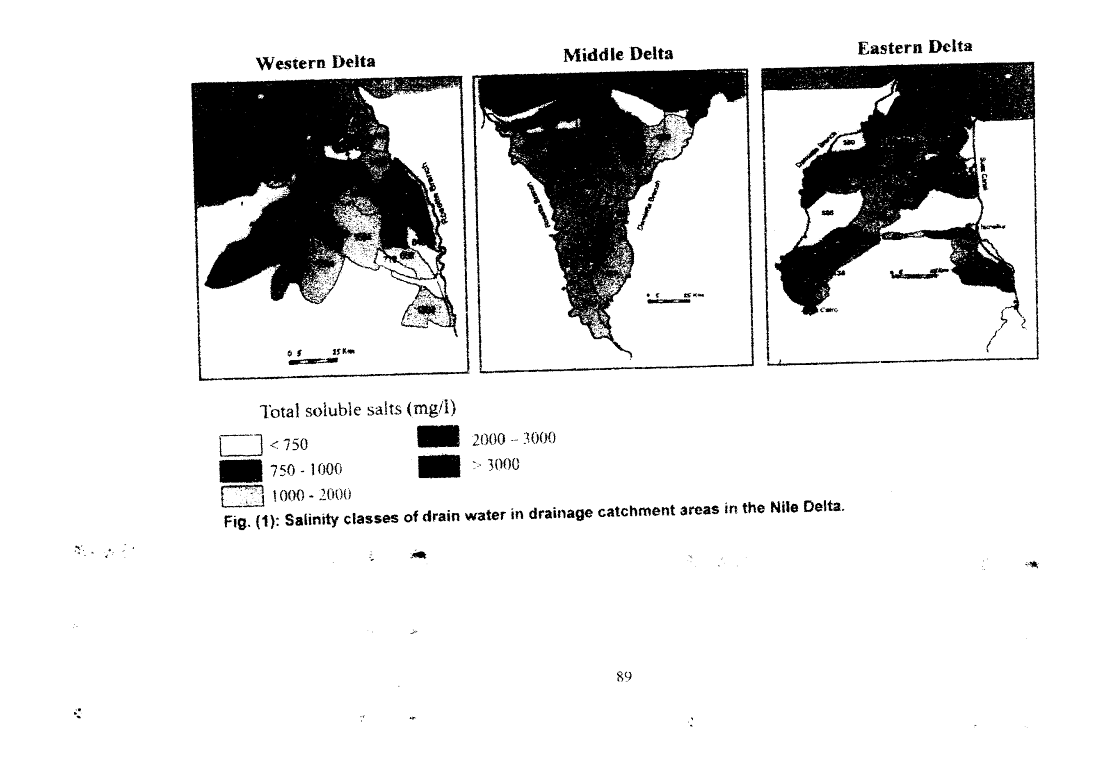


Fig. (1): Salinity classes of drain water in drainage catchment areas in the Nile Delta.

Table (2): Chemical analysis of water samples (yearly average) from drains and mixed canals of Middle Delta.

Code No.	EC (dS/m)	T.S.S (mg/L)	(meq/L) $CO_3^{=}$	CO_3^{-}	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	RSC	SAR	Adj SAR	pHc calculated
M1	1.85	1184	-	5.76	5.26	8.82	5.54	5.81	8.21	0.37	0.60	4.24	9.78	6.85
M2	1.66	1064	-	4.63	5.05	7.99	5.82	4.70	6.86	0.28	0.16	3.72	8.20	6.99
M3	1.88	1205	-	5.45	6.96	7.67	5.54	4.52	9.73	0.30	0.64	5.29	12.16	6.95
M4	6.28	4019	-	5.67	36.19	15.66	16.46	17.02	38.66	0.46	-	11.97	32.10	6.70
M5	2.20	1408	-	4.75	8.99	9.55	6.03	5.62	11.30	0.34	0.19	5.92	12.78	6.86
M6	2.76	1765	-	5.03	12.12	12.42	7.83	7.63	13.78	0.33	-	6.22	14.18	6.80
M7	3.58	2291	-	4.67	16.68	16.99	7.41	11.11	19.41	0.41	-	8.13	17.58	6.70
M8	7.26	4646	-	5.46	45.39	35.52	10.90	26.27	48.46	0.75	-	15.13	38.60	6.70
M9	10.59	6779	-	7.99	72.03	51.03	11.65	30.16	86.82	1.59	-	24.11	65.52	6.40
M10	4.84	3098	-	5.51	36.91	11.42	4.83	10.00	38.22	0.84	-	13.99	35.64	6.85
M11	7.46	4777	-	5.96	49.10	33.07	10.96	25.29	50.97	0.93	-	15.86	42.58	6.65
M12	6.29	4028	-	5.09	35.10	32.05	9.33	18.77	43.42	0.71	-	14.95	36.64	6.70
M13	5.75	3680	-	6.00	32.34	26.40	10.24	16.18	37.67	0.65	-	13.29	34.17	6.65
M14	2.51	1606	-	5.50	8.91	10.65	6.36	6.49	11.84	0.38	-	5.54	12.88	6.87
M15	2.71	1733	-	5.49	11.15	11.31	6.97	6.95	13.68	0.34	-	6.33	13.73	6.60
M16	3.97	2541	-	5.74	23.92	14.11	5.53	11.55	26.08	0.61	1.12	10.97	26.77	6.80
M17	1.76	1129	-	4.10	7.10	6.54	2.80	3.34	11.27	0.34	-	6.28	12.90	7.24
M18	1.99	1272	-	3.70	9.21	7.08	2.47	4.03	13.08	0.41	0.65	6.73	13.72	7.25
M19	2.18	1392	-	5.43	6.79	10.52	6.42	6.24	9.57	0.31	0.22	4.89	11.21	6.86
M20	2.67	1707	-	4.92	12.04	11.47	6.95	7.86	13.25	0.37	-	5.63	12.61	6.80

Table (2): Cont.

Code	EC	T.S.S	(meq/L)								RSC	SAR	Adj.	pHc
No.	(dS/m)	(mg/L)	$CO_3^=$	CO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+			SAR	calculated
M21	2.12	1356	-	5.46	4.04	12.99	6.44	7.06	8.77	2.83	0.12	4.34	9.86	6.81
M22	2.39	1527	-	6.09	3.26	19.45	9.47	8.14	7.64	3.56	0.93	3.57	8.28	6.68
M23	2.33	1493	-	6.56	4.20	14.59	8.84	7.45	8.83	0.24	-	3.76	8.93	6.73
M24	2.79	1788	-	4.74	16.26	7.21	3.91	5.82	18.20	0.40	-	8.38	18.19	7.05
M25	1.55	992	-	5.09	2.54	8.52	5.71	4.17	6.06	0.22	0.42	3.28	7.30	6.92
M26	2.53	1620	-	4.67	16.53	4.26	3.07	5.05	16.86	0.43	-	8.50	17.77	7.13
M27	1.89	1210	-	5.50	3.07	8.36	6.36	5.97	7.23	0.27	0.50	3.60	8.35	6.85
M28	10.03	6420	-	6.66	88.69	22.82	4.93	20.73	91.08	1.44	-	25.38	64.78	6.65
M29	0.69	443	-	2.84	1.04	3.35	3.02	2.26	1.71	0.19	-	1.29	2.14	7.35
M30	1.63	1043	-	3.83	4.83	8.72	5.61	4.48	7.06	1.86	0.06	3.83	7.86	7.04
M31	0.77	493	-	3.30	0.88	3.86	3.96	1.99	1.93	0.18	0.31	1.38	2.50	7.30
M32	0.94	599	-	3.69	0.96	6.94	3.98	2.83	2.71	2.25	0.51	1.70	3.52	7.12
M33	0.72	458	-	3.00	0.78	3.64	3.52	2.04	1.70	0.16	0.26	1.29	2.21	7.30
M34	0.81	515	-	3.25	0.93	4.12	4.09	1.79	2.25	0.17	0.26	1.63	2.93	7.31
M35	0.68	432	-	2.88	0.66	3.45	3.17	1.99	1.57	0.16	0.27	1.17	1.98	7.34
M36	0.75	477	-	2.98	0.69	3.98	3.40	2.34	1.75	0.16	0.28	1.27	2.24	7.30
M37	0.68	435	-	3.08	0.80	4.18	4.03	2.02	1.82	0.19	0.29	1.26	2.14	7.30
M38	1.15	733	-	3.03	0.69	3.27	3.45	1.72	1.65	0.16	0.34	1.32	2.27	7.34

The adj. SAR values of drain water of Samatay, Sabal, ElNaseria, and El-Qarnien drains ranged from 8.20 to 8.93. They are classified as "slight to moderate". However, the rest of drains ranged from 9.78 to 65.52 and classified as "sever". Therefore, hazard due to soil permeability problem in long run application of these drains may occur. The calculated pHc values of all drains is less than 8.4, which means that the soluble calcium from drain water tends to precipitate in soil irrigated with such water.

Concerning irrigation canals which mixed with drains water (Nile at Kafr El-Zayat, Mit Yazid, El-Riah El-Abassi, and Nile at ElMahalah), the total soluble salts before and after mixing with Taia (1356 mg/l), Toukh (992 mg/l), El-Qarnien (1493 mg/l) and ElNaseria (1210 mg/l), respectively did not change before and after with these drains. They ranged before and after (493-599 mg/l); (458-5 15 mg/l), (432-477 mg/l) and (435-733 mg/l), respectively. They are classified as "none" in the degree of restriction in use for irrigation. On the other hand, Bahr Tira canal is classified as "slight to moderate" because the total soluble salts ranged from 443 to 1043 mg/l before and after mixing with Ei-Gharbia drain at Ei-Hamui (1408 mg/l). This is mainly due to high content of total soluble salts of El-Gharbia drain and heavy clay soils served, which cause salinity and sodicity problems in this reclaimed area.

*c- **Western Delta:***

The total soluble salts of drain water ranged from 640 to 5617 mg/l, whereas adj. SAR values ranged from 6.36 to 52.57. The calculated pHc of water ranged from 6.65 to 7.24.

From the obtained data, it could be noticed that drain water of Etay Ei-Baroud, Bishara, Zarqun, Idko Irrigation, Ei-Dilingat, ElKhandak Ei-Gharbi, El-Khairy and El-Omoum at Maruit pumping station have total soluble salts less than 1000 mg/l (30.4% of total samples). They are ranged from 640 to 992 mg/l. The total soluble salts of Halq Ei-Gamai, Ei-Qusor, El-Bousiiy, El-Tabia, Ei-Shershera, Abu Humos, Ei-Qalaa, Burg Rashid and El-Boustan drains are ranged from 1245 to 1769 mg/l (39.1% of total samples). It could be concluded that these drains can be reused directly or by mixing with canal water without causing severe problems with some precautions according to Ayers and Westcot (1985). Their total soluble salt values are less than 2000 mg/l.

The total soluble salts of Truga and Mohit Idko drains have 2263 and 2467 mg/l, respectively (8.7% of total samples). The rest of drains contain, total soluble salts ranged from 3086 to 5617 mg/l (21.7 of the total samples) namely. El-Dushudy, Hares, Abies, El-Omoum, West Nubaria drains. These drains are considered highly saline water and classified as "severe" in the degree of

restriction in use and may cause soil salinity problem in long run application. This is mainly due to the following reasons.

- None official reuse of drainage water, which causes a corresponding, increase in drainage water salinity.
- Seepage of seawater inland coupled with the normal sub soil water, which should have already acquired some salinity during its flow with descending gradient of land surface northward.
- New reclaimed area of North part of Delta, which have high soil salinity.

It is observed also, a high soluble salts in West Nubaria drain, which discharged to the Mediterranean Sea by gravity. It reached 3086 gm/i, this is mainly due to the high salinity of some drains namely, No. 6, Koubri Massoud, El-Horiya, Ei-Nour and Ei-Tahrir which discharged its water to west Nubaria drain with salinity 2368, 2284, 1280, 2768 and 1508 mg/l, respectively. This drain is classified as "severe" in the degree of restriction in use for irrigation. Therefore, salinity and alkalinity hazard in long run reuse well occur.

The adj. SAR values of drain water of Etaiy El-B aroud ElDilingat., Ei-Khandak El-Gharbi and Ei-Khairy drains ranged from 6.36 to 8.72. They are classified as "slight to moderate". However, in the rest of drains, adj. SAR values are ranged from 9.77 to 57.57 and classified as "severe". Therefore, hazards may occur due to soil permeability problem in long run application. The calculated pHc of all drains is less than 8.4, which means that the soluble calcium from drain water tends to precipitate in soil irrigated with such water.

Concerning irrigation canals which mixed with drains water (Ei-Khandak Ei-Sharqi, El-Hager & Frhash, Abu Diab and ElMohmoudia canals), the total soluble salts before and after mixing with Etay Ei-Baroud (640 mg/l), El-Diingat (716 mg/l), El-Khandak El-Gharbi (660 mg/l), and Idko drains (990 mg/l) ranged (297-451 mg/l), (279-297 mg/l),(372-492 mg/l) and (369-431 mg/l), respectively. They are classified as "nones' in the degree of restriction in use for irrigation. On the other hand, El-Nubaria canal has slightly soluble salts after mixing with El-Boustan km29 (1384 mg/l) , No.1-km 54 (1908 mg/l) and No.3 km 55 (2132 mg/l) drains. It ranged (580 to 904 mg/l), (320 to 844 mg/l) and (472 to 1532 mg/l), respectively. It could be classified as "slight to moderate" jn the degree of restriction in use. The mixing water with Ei-Omoum drain is deliver low soluble salts (924 mg/l), it reached before and after mixing (617-796 mg/l) at Nubaria canal (km 86).

Table (3): Chemical analysis of water samples (yearly average) from drains and mixed canals of Western Delta.

Code No.	EC (dS/m)	T.S.S (mg/L)	$CO_3^=$	CO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+	RSC	SAR	Adj. SAR	pHc calculated
			(meq/L)											
W1	1.00	640	-	4.50	2.27	3.36	2.33	2.64	4.90	0.27	0.51	3.00	6.36	7.22
W2	1.30	832	-	4.59	3.22	5.44	2.61	2.62	7.69	0.33	0.29	4.66	10.18	7.24
W3	1.52	972	-	4.78	4.52	7.59	2.70	2.95	10.90	0.35	0.17	6.91	14.04	7.17
W4	1.55	992	-	4.36	6.43	4.90	2.78	3.19	9.34	0.37	0.22	5.20	11.66	7.22
W5	1.12	716	-	4.91	1.78	4.68	3.15	2.52	5.46	0.25	-	3.23	7.12	7.13
W6	1.03	660	-	4.78	1.92	3.84	2.48	2.54	5.21	0.22	0.64	3.31	7.21	7.17
W7	1.21	777	-	5.37	3.61	3.40	2.84	2.82	6.39	0.33	0.49	3.80	8.72	7.14
W8	1.95	1245	-	4.83	10.53	4.29	2.66	4.55	12.01	0.43	-	6.20	13.50	7.05
W9	2.41	1545	-	5.33	13.06	4.35	2.82	5.11	16.07	0.48	-	7.95	17.57	7.07
W10	2.24	1431	-	4.66	13.88	4.48	2.47	5.15	14.88	0.52	-	7.41	16.32	7.01
W11	3.54	2263	-	5.57	22.04	8.73	4.13	6.88	24.68	0.66	-	10.34	24.47	6.90
W12	2.37	1516	-	5.41	12.83	5.56	3.32	4.52	15.43	0.58	1.18	7.83	17.26	7.01
W13	1.91	1225	-	4.74	11.16	3.43	2.62	4.25	12.01	0.45	-	6.43	13.56	7.09
W14	2.49	1594	-	5.77	9.49	9.89	4.17	4.77	15.76	0.46	-	7.43	16.56	7.02
W15	2.64	1690	-	5.07	11.65	8.39	3.50	4.56	16.53	0.42	-	8.15	17.76	7.07
W16	3.85	2467	-	5.63	19.95	14.79	5.55	7.75	26.33	0.73	-	10.09	25.90	6.85
W17	5.04	3226	-	5.62	33.61	16.15	6.94	10.29	37.51	0.91	-	12.50	33.12	6.65
W18	8.78	5617	-	5.01	66.61	32.07	10.53	22.37	69.42	1.36	-	17.08	45.72	6.70
W19	7.95	5091	-	5.69	64.20	24.45	8.11	19.25	65.62	1.34	-	17.34	45.30	6.65
W20	2.82	1807	-	5.45	17.97	5.09	3.59	5.72	18.42	0.77	-	8.47	19.20	6.95
W21	8.46	5414	-	4.97	61.21	32.59	7.70	17.74	71.96	1.37	-	20.46	52.57	6.70
W22	2.76	1769	-	5.22	18.37	5.49	3.62	5.44	19.56	0.47	-	8.40	18.94	7.00
W23	0.46	297	-	2.99	0.61	1.15	1.78	1.16	1.65	0.16	0.51	2.19	3.59	7.31
W24	0.70	451	-	3.62	1.56	2.02	2.24	1.73	5.41	0.20	0.25	2.07	3.98	7.37
W25	0.44	279	-	2.98	0.71	0.79	1.68	1.17	1.46	0.16	0.52	1.22	2.00	7.71
W26	0.46	297	-	3.00	0.64	1.04	1.83	1.22	1.46	0.16	0.43	1.19	1.98	7.51

Table (3): Cont.

Code No.	EC (dS/m)	T.S.S (mg/L)	(meq/L)								RSC	SAR	Adj. SAR	pHc calculated
			$CO_3^{=}$	$CO_3^{=}$	Cl^-	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^+	K^+				
W27	0.58	372	-	3.49	1.22	1.26	2.05	1.24	2.47	0.17	0.48	1.80	3.53	7.48
W28	0.77	492	-	3.80	1.51	2.56	2.31	1.91	3.47	0.19	0.42	2.31	4.57	7.35
W29	0.58	369	-	3.21	1.03	1.69	2.02	1.47	2.25	0.18	0.53	1.68	3.04	7.53
W30	0.67	431	-	3.47	1.66	1.70	2.25	1.55	2.82	0.31	0.41	2.04	3.77	7.41
N1	2.98	1908	-	4.44	12.67	13.10	3.80	4.36	21.60	0.46	-	10.73	21.93	7.15
N2	3.33	2132	-	3.97	14.60	15.03	6.19	4.70	22.48	0.49	-	9.64	20.66	7.10
N3	3.21	2052	-	3.86	12.65	16.02	6.83	4.41	20.69	0.47	-	8.65	18.60	7.05
N4	3.70	2368	-	3.98	15.85	17.66	6.86	5.24	25.25	0.51	-	10.27	23.57	7.00
N5	3.57	2284	-	3.96	11.23	21.20	8.90	5.40	21.59	0.50	-	8.14	18.83	4.55
N6	2.00	1280	-	3.94	4.70	11.55	6.35	3.46	10.06	0.32	-	4.44	9.45	7.05
N7	4.33	2768	-	4.10	13.39	28.79	12.45	5.89	27.46	0.48	-	9.05	21.72	6.80
N8	2.36	1508	-	3.52	5.90	14.55	7.61	3.88	12.13	0.34	-	5.06	11.45	6.94
N9	1.44	924	-	3.74	6.14	4.85	3.22	2.70	8.49	0.32	-	4.68	9.77	7.21
N10	4.82	3086	-	4.05	23.12	26.34	11.65	9.87	31.47	0.52	-	9.57	22.27	6.80
N11	5.10	3264	-	4.59	41.60	31.36	5.61	16.54	34.44	0.96	-	10.35	25.36	6.75
N12	2.16	1384	-	3.77	5.49	12.65	6.92	3.52	11.24	0.24	-	4.94	10.73	7.05
N13	0.91	580	-	2.92	0.80	0.90	1.73	1.27	1.47	0.15	-	1.20	4.75	7.51
N14	1.41	904	-	3.26	1.85	4.24	3.03	1.93	4.26	0.17	-	2.59	2.01	7.47
N15	0.96	617	-	3.05	3.07	3.56	2.93	1.62	5.06	0.19	-	3.32	6.43	7.37
N16	1.24	796	-	3.52	4.95	4.11	3.01	2.41	6.86	0.30	-	4.03	8.08	7.34
N17	4.81	3081	-	3.44	30.40	19.27	5.50	6.87	40.27	0.47	-	16.94	35.14	7.05
N18	2.90	1856	-	3.63	16.22	9.62	4.85	5.29	18.91	0.42	-	7.97	17.00	7.15
N19	3.81	2436	-	3.70	19.90	15.52	6.86	6.99	24.84	0.43	-	9.62	22.24	7.00
N20	0.50	320	-	2.90	0.89	1.34	2.00	1.35	1.62	0.17	-	1.27	2.16	7.52
N21	1.32	844	-	3.27	4.92	5.18	2.36	2.30	8.52	0.25	-	5.31	9.92	7.40
N22	0.74	472	-	3.08	2.14	2.43	2.11	1.43	3.92	0.18	-	2.96	5.08	7.50
N23	2.39	1532	-	3.62	10.15	10.37	4.63	3.31	15.88	0.34	-	7.81	16.26	7.22

CONCLUSION

To achieve safe use of drainage water in irrigation, many practices can be combined. The appropriate combination depends upon strategies of water, soil and plant. Soil management (tiilage, organic and green manures, deep ploughing, sanding and chemical amendments) should be done. A selection of crops or crops tolerant varieties and special planting should be taken into consideration.

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الملخص العربي

التقييم البيئى لمياه المصارف فى دلتا النيل لتحقيق التنمية الزراعية المستدامة:

أ- الأملاح الكلية الذائبة

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تمت هذه الدراسة لتقييم نوعية مياه مصارف الدلتا التى تستخدم فى الرى من حيث احتوائها على الأملاح الكليه الذائبة. حيث أخذت عينات من مياه المصارف وكذا الترع المخلوطة خلال الفترة من يونيو ١٩٩٩ وحتى مايو ٢٠٠٠ من منطقة شرق ووسط وغرب الدلتا وكانت النتائج المتحصل عليها: فى شرق الدلتا... يحتوى ٤٥% من مياه مصارف بحر البقر على املاح كليه ذائبة تقل عن ٢٠٠٠ ملليجرام / لتر وصنفت على انها خفيفة إلى متوسطة الملوحة بينما ٥٥ % منها تزيد عن ٢٠٠٠ ملليجرام / لتر وصنفت على انها شديدة الملوحة. وكذلك فإن ٩٢,٣ % من مياه مصارف بحر حادوس تقل ملوحتها عن ٢٠٠٠ ملليجرام. وقد صنفت قيم adj. SAR من خفيفة إلى متوسطة فى منطقتى بحر البقر وبحر حادوس وكان متوسط قيم pH c المحسوبة لجميع العينات يقل عن ٤ و ٨ مما يدل على ترسيب الكالسيوم الذائب من مياه المصارف بالأراضى التى تروى بها. لم توجد إختلافات فى نوعيه مياه الترع المخلوطة من حيث الأملاح الكلية الذائبة قبل أو بعد الخلط بمياه المصارف حيث تراوحت كمياتها من ٢٤٢-٥٩٧ ملليجرام / لتر وتعتبر غير ملحيه بينما صنفت مياه ترعه نفان وترعه السلام بانها متوسطة الملوحة حيث بلغ تركيز الأملاح الكلية الذائبة ١٤٦٠، ٩٨٨ ملليجرام / لتر على التوالى. فى وسط الدلتا... تحتوى ٦٤ ٥/ه من عينات مياه مصارف منطقه وسط الدلتا على املاح كليه ذائبة تقل عن ٢٠٠٠ ملليجرام / لتر وصنفت من خفيفة إلى متوسطة بينما ٣٦%منها تزيد عن ٢٠٠٠ ملليجرام / لتر وصنفت شديدة الملوحة. وقد اظهرت قيم adj. SAR انها خفيفة إلى متوسطة وشديدة بينما قدرت قيم pHc المحسوبة لجميع العينات فكانت تقل عن ٨,٤ مما يدل على ترسيب الكالسيوم الذائب من هذه المياه للتربة التى تروى بها لم توجد اختلافات فى نوعية مياه الترع المخلوطة من حيث الأملاح الكلية الذائبة قبل او بعد الخلط من مياه المصارف حيث تراوحت تركيز الأملاح الكلية الذائبة قبل وبعد الخلط من ٤٣٢-٥٩٩ ملليجرام / لتر وتعتبر هذه المياه غير ملحية. بينما إرتفعت ملوحة مياه بحر تيرة بعد خلطها بمصرف الغربية إلى ١٠٤٣ ملليجرام / لتر حيث صنفت خفيفة إلى متوسطة فى غرب الدلتا يحتوى ٦٩,٦ه/ه من مياه عينات مصارف غرب الدلتا على املاح كلية ذائبة تقل عن ٢٠٠٠ مليجرام/ لتر وصنفت من خفيفة إلى متوسطة بينما ٣٠,٤ ه/ه منها تزيد عن ٢٠٠٠ مليجرام / لتر وصنفت شديدة الملوحة. بينما صنفت قيم adj. SARمن خفيفة إلى متوسطة وشديدة الملوحة على التوالى اما قيم pH c المحسوبة لجميع العينات فكانت اقل من ٨,٤ مما يدل على ترسيب الكالسيوم الذائب من هذه المياه فى التربة التى تروى منه. لم توجد إختلافات فى نوعية مياه الترع المخلوطة قبل او بعد الخلط من مياه المصارف حيث تراوح تركيز الأملاح الكلية الذائبة من ٢٧٩-٤٩٢ مليجرام / لتر وتعتبر هذه المياه منخفضة الملوحة بينما كانت مياه ترعة النوبارية متوسطة الملوحة حيث صنفت من خفيفة إلى متوسطة حيث تراوح تركيز الأملاح بها من ٨٤٤- ١٥٣٢ مليجرام / لتر بعد الخلط بمياه مصارف البستان (كم ٢٩)، مصرف أ (كم ٤)، مصرف ٣ (كم ٥٥)، العموم بمريوط (كم ٨٦.)

Environmental Assessment of Drainage Water in Nile Delta for Sustainable Agricultural Development: II- Elements Hazard

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ABSTRACT

This study were carried out to assess the drainage water quality for reusing irrigation. Samples of drainage water (each represent drain or Canal) were taken monthly during the period from June, 1999 to May, 2000 for Nile Delta. The results indicated that:

- In Eastern Delta, all drains or mixing canals in both area (Bahr El-Baqr and Bahr Hadus) have a content of the tested elements (N, P, K, Zn, Fe, Mn, Cu, Pb, Co, Ni, Cr, Cd, and B) below the critical limits except that 20%, 15%, and 15% for Boron, Manganese and Ammonia, respectively for the collected samples of Bahr El-Baqr area have a concentration exceed the critical limits.
- In Middle Delta, all the determined elements in water samples of drains or mixing canals are within the safe limits.
- In Western Delta, most of the determined elements are within safe limits. Boron concentration shows that 21.7% of total collected samples are more than 0.75 mg/L which is classified as "slight to moderate" grade. A 4.3% of the total samples is more than 5.0 mg/L of NH_4 ions and classified as "slight to moderate" grade.

Keywords: Environment, drainage, irrigation, quality, elements.

INTRODUCTION

Excessive use of chemical fertilizers and pesticides may cause contamination of drainage water by some chemical compounds. On the other hand, the disposal of municipal and industrial wastes into the network of drainage system pollutes their water by heavy metals. These metals are considered potentially when reaching high level incredible parts of the crop. The enhancement of industrial activities led to an increase in heavy metals in the environment (water, soil and plant). These effects are related to the disposal of wastes of some factories to drains or canals (El-Zahby et al., 1986) and (El-Kassas et al., 1994). These wastes provide heavy metals to the environment, which affected badly in soil properties. The amounts of heavy metals in drains received industrial wastes were higher than that observed in those received only municipal refuses in both the levels of heavy metals where they found to be higher than that in Nile water (Rabie, 1986).

Ghazy (1988) found that the heavy metals contents in El-Gharbia main drain were lower than the permissible levels except Cd, which is exceed the safe limits. El-Wakeel and El-Mowelhi (1990) reported that 12.61 of the drainage water discharged in the Middle Delta have B concentration more than critical limits (> 0.75 mg/L). Whereas, heavy metals (Mn, Cd and Co) surpass the recommended levels by 9.9, 8.2 and 15% of the discharged water, respectively. The other tested elements (Fe, Zn, Cu, Co, Pb and Li) were considered safe.

El-Mowelhi et al., (1995) reported that 62.5% of drainage water discharged in Western Delta have B concentration exceed critical limits. Heavy metals (Fe, Zn, and Li) were considered safe, while the other tested elements were surpassed the recommended levels (Mn, Cu and Ni).

The suitability of drainage water for irrigation based on guidelines established by Egyptian Decree No.16 of law 93/1962 recommended by committee (1995) and National Academy of Engineering & National Academy of Science (1972). These recommended limits help to identify the hazards of some elements in drainage water.

Finally, All heavy metals are aggressive environmental pollutants. They are easily taken up by plants and they are strong stress factors for plant metabolism and plant mineral nutrition (Siedlecka, 1995).

The ultimate goal of this study is to obtain accurate information related to the quality of drainage water at strategic locations along the main drains in the Nile Delta where significant changes of hazard of some elements due to the addition to or withdrawal from the drain.

MATERIALS AND METHODS

To assess the drainage water quality for reusing it in irrigation. Samples of drainage water (each represent drain or canal) were collected monthly during the period from June, 1999 to May, 2000 for Nile Delta. The samples were analyzed immediately to include:

- Soluble NO_3 & NH_4 were determined according to Markus et al., (1982) by using Technicon Auto-Analyzer, Method No. 763-85 (GT)A.
- Soluble (P, Zn, Cu, Mn, Fe, Cd, Pb, Co, Ni, Cr and B) were determined by using Inductively Coupled Plasma Spectrometry (ICP 400).

Three main parts of Nile Delta drains were divided the region to East, Middle and West. These are:

1- Eastern Delta drains:

Code No.	Drain name	Code No.	Drain name
E1	El-Qalubia	E25	El-Wadi El-Sharqi canal "after" mixing
E2	Belbies	E26	Abu El-Akhder canal "before"
E3	Bahr El-Baqr inlet	E27	Abu El-Akhder canal"after"
E4	Blad El-Ayed	E28	El-Salam at Sahret B. El-Baqr km 70
E5	El-Arin	E29	El-Serw Al-Alaa
E6	El-Saada	E30	Farskur
E7	Qahbuna	E31	El-Serw Al-Asfal
E8	Bahr El-Baqr 1	E32	El-Matana
E9	Bahr El-Baqr 2	E33	Omoum El-Behira Al-Asfal
E10	Ganub Port Said	E34	Omoum El-Behira Al-Alaa
E11	Ganub El-Hessania	E35	El-Fanan
E12	Bahr El-Baqr outlet	E36	El-Qasabi
E13	Shamal Ismalia	E37	Bahr Facous
E14	El-Mahsama	E38	Saft El-Qebli
E15	El-Manief	E39	Zarfodaki
E16	El-Wadi	E40	El-Nizam
E17	Gabal Mariem	E41	El-Senblawin
E18	El-Malaria 1.	E42	Bahr Hadus "outlet"
E19	El-Malaria 2.	E43	Nile at Damyiata "before"
E20	El-Ganien El-Bahri	E44	Nile at Damyiata "after"
E21	El-Ganien El-Qebli	E45	Hanut canal "before"
E22	Genifa	E46	Hanut canal "after"
E23	Shandura	E47	Dafan canal "before"
E24	El-Wadi El-Sharqi canal "before" mixing	E48	Dafan canal "after"

2- Middle Delta drains:

Code No.	Drain name	Code No.	Drain name
M1	El-Sagaiya	M20	El-Mandura
M2	Samatay	M21	Tala
M3	No. 5	M22	Sabai
M4	Ibshan	M23	El-Qarnien
M5	El-Gharbia	M24	No. 2
M6	No. 4	M25	Toukh
M7	No. 3	M26	No. 1
M8	No. 5	M27	El-Nasria
M9	El-Brolus	M28	El-Senanya
M10	El-Gharbia "outlet"	M29	Tira canal "before"
M11	Hafir Shehab El-Deen	M30	Tira canal "after"
M12	No. 7 Al-Asfal	M31	Tala canal "before"
M13	No. 8 Al-Asfal	M32	Tala canal "after"
M14	No. 9	M33	Mit Yazid canal "before"
M15	No. 9 "outlet"	M34	Mit Yazid canal "after"
M16	El-Zieni	M35	El-Riah Al-Abass "before"
M17	No. 11	M36	El-Riah Al-Abass "after"
M18	Mohit Zaghloul	M37	Nile at El-Mahllah "before"
M19	Nashart	M38	Nile at El-Mahllah "after"

3- Western Delta drains:

Code No.	Drain name	Code No.	Drain name
W1	Etay El-Baroud	N1	No. 1
W2	Beshara	N2	No. 3
W3	Zarqun	N3	West Nubaria Drain "inlet"
W4	Idko Irrig	N4	No. 6
W5	El-Dilingat	N5	Koubri Massoud
W6	El-Khandak El-Gharbi	N6	El-Houria El-Nour
W7	El-Khairy	N7	El-Nour
W8	Halq El-Gamal	N8	El-Tahrir
W9	El-Qusor	N9	El-Omoum, Mariut
W10	El-Bousily	N10	West Nubaria "outlet"
W11	Mohit Idko	N11	West Nubaria (km 21)
W12	El-Tabia	N12	El-Boustan
W13	Idko "outlet"	N13	El-Nubaria canal "before" (km 29)
W14	El-Shershra	N14	El-Nubaria canal "after" (km 29)
W15	Abu Humos	N15	El-Nubaria canal "before" (km 86)
W16	Truga	N16	El-Nubaria canal"after" (km 86)
W17	El-Dushudy	N17	Oil waste company
W18	Hares	N18	Navigation canal of El-Nubaria "before"
W19	Abies	N19	Navigation canal of El-Nubaria "after"
W20	El-Qalaa	N20	El-Nubaria canal "before" (km 54)
W21	El-Omoum, Max	N21	El-Nubaria canal "after" (km 54)
W22	Bourg Rashid	N22	El-Nubaria canal "before" (km 55)
W23	El-Khandak El-Sharqi canal "before"	N23	El-Nubaria canal "after" (km 55)
W24	El-Khandak El-Sharqi canal "after"		
W25	El-Hager & Frhash canal "before"		
W26	El-Hager & Frhash canal "after"		
W27	Abu Diab canal "before"		
W28	Abu Diab canal "after"		
W29	El-Mahmudia canal "before"		
W30	El-Mahmudia canal "after"		

3. RESULTS AND DISCUSSIONS

Macro and micro nutrients concentration in drain water and mixed canal are presented in Tables (1, 2 and 3) for Eastern, Middle and Western Delta, respectively. These elements are nessary to plant growth and may be reduce crop quality in high concentration. From the obtained data, the yearly average concentration is below the critical limits for irrigation according to the Egyptian guidelines. Whereas, in some drains such as Bahr El-Baqr drain in Eastern Delta has high concentration of NH_4-N which exceed the critical limits (> 0.5 mg/l), it is classified as "slight to moderate" in the degree of the restriction in use for irrigation because of most polluted drains discharged in Bahr El-Baqr drain are El-Qalubia and Belbies drains. Their values are 14.5 and 14.04 mg/l, respectively. It reached 7.6 mg/l at Bahr El-Baqr outlet. At Western Delta, El-Qalaa drain is the most polluted drain with NH_4-N (17.00 mg/l), it represents 4.3% of the total samples, while El-Nour drain in West Nubaria area reached (6.92 mg/l). While at Middle Delta, the values still below the critical limits.

Excessive phosphorous has not been a problem for irrigation purposes and no guidelines value is given for its evaluation, but evaluation of P in drains water may be valuable for fertilization planing.

Micronutrients in drain water are presented in Tables (1, 2 and 3) for Eastern, Middle and Western Delta. These elements are necessary to plant growth and may be toxic to sensitive crops in high concentrations. From the obtained data, the yearly average concentration is below the critical limits for irrigation as the Egyptian guideline (1995) and NAE and NAS (1972). Manganese is found in high concentration in El-Qalubia, Belbies and Bahr El-Baqr drains in Eashern Delta which exceed the critical limits (>0.2 mg/l). Their concentration is 0.25, 0.24, 0.27 mg/l, respectively (15% of the total samples wastes of some factories to these drains in this area.

Heavy metals content in drains water (yearly average) of Eastern, Middle, and Western Delta are presented in Tables (4, 5 and 6), but boron content is illustrated in Fig (1).

It is noticed from the obtained data, that these metals (Cr, Cd, Pb, Co and Ni) are found in low concentration in drains as well as mixed canals. Therefore, they are still below the permissible limits for crop production as recommended by Egyptian guidelines (1995) and NAE and NAS (1972).

Boron is found in high concentration in some drains in Eastern and Western Delta. Their average values ranged from 0.79 to 2.08 mg/l in Eastern part of Delta, include Sahl Port Said. Shamal Ismalia, El-Manaif, and El-Ganien El-Qebli drains which their values reached 2.08, 1.26, 0.9 and 0.79 mg/l (20% of the total sample of Bahr El-Baqr area). These values are exceeded the critical limits (> 0.75 mg/L) and classified as "slight and moderate". The concentration of Boron in Western Delta drains exceeded the critical limits, these drains namely; Truga, Hares, Abies, El-Omoum, and West Nubaria drains. It reached 0.91, 1.69, 1.17, 1.45 and 2.67 mg/l, respectively (21.7% of the total samples), and classified as "slight of moderate" at the degree of restriction in use for irrigation. It is noticed that West Nubaria drain which flow by gravity to the Mediterranean Sea has sub main drains contains high concentration of Boron. It reached 1.71, 2.41, 1.78, 2.52 and 1.45 mg/l for No.6, Koubri Massoud, El-Houria, El-Nour and El-Tahrir drains, respectively (30% of the total samples). These concentration of Boron exceed the critical limits and classified as "slight to moderate".

It is observed also, that drains No.1 and No.3 in West Nubaria area polluted El-Nubaria canal by Boron at the site of their discharged to El-Nubaria canal (km 54 and km 55). Their concentration are reached 1.81 and 1.79 mg/l, respectively and classified as "slight to moderate". These values are exceed the critical limits.

Table (1): Annual average values of macro and micro elements concentration in water samples from drains and mixed canals of Eastern Delta.

Location	Code No.	(mg/L)						
		NO_3	NH_4	P	Zn	Mn	Fe	Cu
Bahr El-Baqar area	E1	0.73	14.50	2.957	0.027	0.246	0.080	0.010
	E2	0.72	14.04	3.617	0.014	0.235	0.132	0.010
	E3	0.47	14.73	3.771	0.057	0.269	0.134	0.006
	E4	2.38	0.32	0.453	0.015	0.010	0.058	0.010
	E5	3.48	0.70	1.014	0.071	0.074	0.133	0.025
	E6	1.81	0.11	0.335	0.008	0.022	0.142	0.010
	E7	1.66	0.31	0.311	0.043	0.026	0.086	0.082
	E8	1.89	0.37	0.484	0.029	0.046	0.046	0.023
	E9	1.24	9.12	2.574	0.023	0.273	0.123	0.019
	E10	2.04	0.36	0.607	0.023	0.054	0.087	0.013
	E11	2.13	0.19	0.502	0.064	0.042	0.261	0.018
	E12	1.92	7.60	1.412	0.015	0.153	0.088	0.012
	E13	2.08	0.08	0.496	0.031	0.031	0.066	0.007
	E14	2.03	0.17	0.304	0.013	0.047	0.093	0.007
	E15	2.08	0.07	0.302	0.010	0.024	0.022	0.011
	E16	1.63	0.16	0.382	0.026	0.028	0.105	0.046
	E17	1.86	0.16	0.355	0.034	0.018	0.090	0.013
	E18	4.45	0.13	0.527	0.013	0.010	0.034	0.008
	E19	4.23	0.12	0.501	0.012	0.009	0.033	0.007
	E20	2.19	0.24	0.349	0.026	0.035	0.044	0.029
	E21	1.98	0.48	0.325	0.008	0.014	0.029	0.006
	E22	3.89	0.09	0.307	0.059	0.011	0.172	0.009
	E23	2.61	0.30	0.252	0.021	0.012	0.075	0.046
	E24	1.20	0.09	0.334	0.008	0.005	0.024	0.011
	E25	1.62	0.17	0.343	0.014	0.009	0.071	0.012
	E26	0.88	0.12	0.380	0.004	0.006	0.055	0.007
	E27	1.62	0.10	0.335	0.005	0.012	0.068	0.014
	E28	1.79	0.18	0.412	0.012	0.041	0.406	0.012
Bahr Hadus area	E29	3.71	0.13	0.370	0.049	0.043	0.043	0.011
	E30	3.01	0.20	0.443	0.030	0.007	0.043	0.010
	E31	3.00	0.10	0.406	0.016	0.008	0.186	0.009
	E32	3.19	0.45	0.345	0.013	0.013	0.187	0.023
	E33	3.42	0.15	0.481	0.025	0.013	0.148	0.010
	E34	4.01	0.70	0.531	0.018	0.015	0.058	0.009
	E35	3.10	0.16	0.551	0.011	0.026	0.153	0.014
	E36	3.97	0.16	0.537	0.015	0.008	0.120	0.009
	E37	3.28	0.39	0.341	0.012	0.036	0.170	0.011
	E38	3.03	0.44	0.607	0.009	0.027	0.057	0.009
	E39	4.03	0.24	0.575	0.013	0.012	0.101	0.010
	E40	4.87	1.65	1.154	0.007	0.048	0.055	0.008
	E41	4.71	0.78	0.755	0.007	0.014	0.111	0.010
	E42	3.03	0.43	0.327	0.013	0.012	0.177	0.022
	E43	1.15	0.00	0.330	0.015	0.005	0.016	0.011
	E44	1.38	0.00	0.396	0.018	0.006	0.019	0.013
	E45	1.05	0.02	0.252	0.007	0.013	0.051	0.007
	E46	1.04	0.11	0.235	0.008	0.013	0.044	0.008
	E47	2.45	0.04	0.322	0.008	0.027	0.116	0.008
	E48	2.61	0.00	0.337	0.012	0.034	0.159	0.011

Table (2): Annual average values of macro and micro elements concentration in water samples from drains and mixed canals of Middle Delta.

Code No.	(mg/L)						
	NO_3	NH_4	P	Zn	Mn	Fe	Cu
M1	1.81	7.08	1.510	0.025	0.149	0.066	0.009
M2	2.74	3.59	0.805	0.009	0.017	0.055	0.007
M3	2.90	0.56	0.527	0.013	0.008	0.029	0.011
M4	2.36	0.20	0.448	0.016	0.153	0.075	0.011
M5	5.55	0.45	0.935	0.013	0.031	0.053	0.009
M6	4.06	0.15	0.635	0.010	0.012	0.043	0.015
M7	2.79	0.14	0.496	0.044	0.029	0.238	0.010
M8	2.54	0.09	0.584	0.050	0.052	0.112	0.011
M9	2.10	0.05	0.509	0.075	0.007	0.065	0.009
M10	2.77	0.04	0.528	0.033	0.027	0.122	0.008
M11	3.14	0.06	0.549	0.031	0.035	0.135	0.014
M12	2.02	0.15	0.360	0.028	0.025	0.216	0.011
M13	2.61	0.09	0.526	0.009	0.047	0.186	0.008
M14	3.76	0.24	0.845	0.007	0.021	0.091	0.005
M15	3.63	0.28	0.764	0.040	0.044	0.179	0.016
M16	2.28	0.05	0.554	0.016	0.050	0.498	0.009
M17	2.35	0.18	0.462	0.013	0.034	0.147	0.007
m18	4.00	1.26	0.433	0.013	0.006	0.134	0.007
M19	4.15	0.28	0.999	0.011	0.013	0.036	0.007
M20	3.99	0.14	0.751	0.015	0.048	0.060	0.009
M21	6.85	0.00	0.471	0.009	0.012	0.070	0.010
M22	5.61	0.58	1.491	0.010	0.011	0.056	0.023
M23	5.06	0.59	0.522	0.008	0.017	0.044	0.008
M24	3.37	0.16	0.447	0.055	0.009	0.108	0.011
M25	3.02	0.16	0.420	0.023	0.014	0.046	0.010
M26	14.54	0.13	0.494	0.027	0.011	0.074	0.010
M27	4.68	0.20	0.846	0.117	0.030	0.035	0.010
M28	3.01	0.39	0.538	0.020	0.182	0.029	0.016
M29	0.96	0.06	0.262	0.012	0.007	0.047	0.008
M30	3.34	0.09	0.572	0.011	0.009	0.040	0.007
M32	1.82	0.00	0.379	0.012	0.015	0.038	0.007
M33	2.68	0.00	0.360	0.012	0.017	0.032	0.006
M33	0.73	0.13	0.598	0.009	0.007	0.020	0.007
M34	1.42	0.08	0.250	0.013	0.008	0.035	0.007
M35	0.62	0.01	0.279	0.008	0.011	0.029	0.008
M36	1.40	0.05	0.358	0.010	0.005	0.023	0.008
M37	1.02	0.04	0.310	0.015	0.007	0.037	0.005
M38	1.56	0.08	0.259	0.011	0.006	0.038	0.006

Table (3): Annual average values of macro and micro elements concentration in water samples from drains and mixed canals of Western Delta.

Code	(mg/L)						
No.	NO_3	NH_4	P	Zn	Mn	Fe	Cu
W1	3.01	0.00	0.335	0.013	0.013	0.093	0.008
W2	3.17	0.00	0.463	0.008	0.008	0.130	0.007
W3	2.69	0.00	0.363	0.007	0.018	0.072	0.007
W4	2.84	0.00	0.455	0.017	0.012	0.123	0.008
W5	1.83	0.00	0.210	0.011	0.009	0.050	0.006
W6	2.90	0.00	0.255	0.053	0.011	0.102	0.008
W7	4.82	1.42	0.897	0.039	0.152	0.073	0.006
W8	2.70	0.00	0.491	0.014	0.017	0.211	0.008
W9	2.84	0.00	0.446	0.014	0.015	0.249	0.008
W10	2.61	0.00	0.452	0.015	0.010	0.191	0.009
W11	2.59	0.00	0.432	0.026	0.021	0.295	0.009
W12	1.77	1.20	0.529	0.033	0.194	0.107	0.009
W13	2.94	0.00	0.585	0.015	0.011	0.119	0.008
W14	3.15	0.00	0.283	0.019	0.007	0.090	0.006
W15	2.68	0.00	0.552	0.016	0.010	0.039	0.008
W16	5.09	0.05	0.277	0.029	0.010	0.104	0.007
W17	3.77	0.00	0.556	0.057	0.021	0.035	0.006
W18	4.94	0.00	0.794	0.049	0.015	0.026	0.007
W19	3.15	0.00	0.412	0.036	0.031	0.026	0.005
W20	1.63	17.00	2.796	0.045	0.212	0.190	0.011
W21	4.46	0.00	0.702	0.077	0.024	0.016	0.007
W22	1.74	0.00	0.340	0.027	0.045	0.048	0.006
W23	0.49	0.00	0.217	0.010	0.004	0.018	0.007
W24	1.50	0.00	0.229	0.012	0.007	0.045	0.007
W25	0.63	0.00	0.196	0.012	0.010	0.048	0.005
W26	0.56	0.01	0.228	0.012	0.006	0.054	0.007
W27	1.36	0.00	0.263	0.010	0.005	0.032	0.006
W28	2.17	0.00	0.250	0.018	0.010	0.073	0.007
W29	1.41	0.00	0.363	0.016	0.005	0.029	0.008
W30	1.92	0.00	0.391	0.013	0.007	0.031	0.006

Table (3): Cont.

Code No.	(mg/L)						
	NO_3	NH_4	P	Zn	Mn	Fe	Cu
N1	2.86	0.00	0.199	0.034	0.008	0.061	0.006
N2	3.56	0.00	0.221	0.024	0.006	0.029	0.006
N3	2.89	0.04	0.163	0.069	0.020	0.034	0.007
N4	3.43	0.00	0.215	0.033	0.007	0.025	0.005
N5	3.56	0.00	0.168	0.034	0.007	0.025	0.005
N6	3.41	0.00	0.161	0.044	0.007	0.018	0.006
N7	6.92	0.00	0.115	0.047	0.006	0.023	0.005
N8	2.93	0.00	0.244	0.053	0.011	0.015	0.006
N9	0.92	0.00	0.166	0.024	0.006	0.029	0.007
N10	4.60	0.00	0.243	0.075	0.008	0.015	0.006
N11	4.47	0.00	0.312	0.008	0.008	0.024	0.006
N12	1.87	0.00	0.163	0.063	0.010	0.016	0.006
N13	0.48	0.00	0.204	0.022	0.007	0.020	0.006
N14	0.78	0.00	0.183	0.016	0.006	0.027	0.007
N15	0.62	0.00	0.251	0.005	0.008	0.034	0.005
N16	1.16	0.00	0.191	0.010	0.009	0.042	0.009
N17	2.50	0.14	0.360	0.038	0.006	0.041	0.007
N18	1.52	0.00	0.233	0.034	0.015	0.040	0.010
N19	2.52	0.01	0.234	0.039	0.016	0.044	0.010
N20	0.49	0.00	0.218	0.017	0.014	0.042	0.019
N21	1.25	0.00	0.198	0.016	0.005	0.037	0.009
N22	0.76	0.00	0.209	0.011	0.008	0.032	0.008
N23	2.11	0.00	0.134	0.018	0.003	0.036	0.005

Western Delta

Middle Delta

Eastern Delta

Boron (mg/L)

< 0.7

0.7 – 3.0

Fig. (1): Boron concentration in drain water of drainage catchment areas in the Nile Delta.

Table (4): Annual average values of some heavy metals concentration in water samples from drains and mixed canals of Eastern Delta.

Location	Code No	(mg/L) Cd	Pb	Co	Ni	Cr	B
	E1	0.005	0.069	0.016	0.020	0.014	0.285
	E2	0.004	0.065	0.016	0.028	0.018	0.407
	E3	0.006	0.052	0.015	0.019	0.018	0.377
	E4	0.004	0.054	0.017	0.018	0.014	0.134
	E5	0.021	0.054	0.017	0.019	0.015	0.179
	E6	0.003	0.049	0.014	0.018	0.015	0.208
	E7	0.004	0.055	0.015	0.015	0.018	0.542
	E8	0.004	0.058	0.017	0.019	0.014	0.405
	E9	0.004	0.064	0.014	0.021	0.015	0.254
	E10	0.004	0.059	0.017	0.019	0.016	2.079
	E11	0.005	0.065	0.017	0.020	0.017	0.536
	E12	0.004	0.064	0.014	0.020	0.013	0.531
	E13	0.005	0.048	0.011	0.021	0.019	1.262
	E14	0.004	0.057	0.013	0.019	0.014	0.325
	E15	0.005	0.060	0.016	0.024	0.017	0.904
	E16	0.004	0.046	0.013	0.020	0.014	0.442
	E17	0.003	0.088	0.016	0.016	0.016	0.462
	E18	0.003	0.057	0.015	0.020	0.013	0.383
	E19	0.003	0.054	0.014	0.019	0.013	0.364
Bahr El-Baqar area	E20	0.002	0.064	0.016	0.050	0.013	0.512
	E21	0.004	0.072	0.018	0.023	0.014	0.788
	E22	0.003	0.079	0.016	0.018	0.021	0.576
	E23	0.004	0.068	0.015	0.022	0.014	0.526
	E24	0.004	0.072	0.015	0.017	0.012	0.114
	E25	0.003	0.097	0.018	0.018	0.014	0.125
	E26	0.003	0.075	0.016	0.019	0.013	0.077
	E27	0.003	0.062	0.016	0.014	0.012	0.145
	E28	0.003	0.073	0.014	0.015	0.012	0.131
	E29	0.006	0.082	0.025	0.019	0.019	0.162
	E30	0.005	0.071	0.015	0.019	0.017	0.121
	E31	0.004	0.090	0.019	0.021	0.016	0.160
	E32	0.002	0.090	0.013	0.020	0.015	0.239
	E33	0.004	0.083	0.015	0.020	0.017	0.221
	E34	0.003	0.084	0.016	0.020	0.013	0.171
	E35	0.005	0.085	0.023	0.021	0.017	0.317
	E36	0.004	0.092	0.020	0.023	0.015	0.151
	E37	0.005	0.073	0.018	0.017	0.014	0.227
Bahr Hadus area	E38	0.003	0.081	0.021	0.020	0.014	0.124
	E39	0.006	0.087	0.016	0.024	0.014	0.159
	E40	0.004	0.090	0.012	0.017	0.014	0.187
	E41	0.003	0.083	0.021	0.018	0.014	0.172
	E42	0.003	0.108	0.015	0.024	0.018	0.286
	E43	0.004	0.085	0.015	0.018	0.015	0.092
	E44	0.004	0.102	0.018	0.022	0.018	0.110
	E45	0.003	0.073	0.017	0.020	0.017	0.087
	E46	0.004	0.089	0.021	0.021	0.015	0.088
	E47	0.003	0.090	0.021	0.020	0.022	0.183
	E48	0.004	0.086	0.019	0.023	0.015	0.180

Table (5): Annual average values of some heavy metals concentration in water samples from drains and mixed canals of Middle Delta.

Code No.	(mg/L)					
	Cd	Pb	Co	Ni	Cr	B
M1	0.006	0.100	0.016	0.025	0.015	0.262
M2	0.005	0.078	0.013	0.025	0.020	0.190
M3	0.005	0.087	0.019	0.024	0.013	0.177
M4	0.005	0.067	0.022	0.023	0.013	0.413
M5	0.005	0.093	0.012	0.024	0.014	0.189
M6	0.004	0.107	0.017	0.028	0.009	0.176
M7	0.004	0.080	0.014	0.024	0.014	0.255
M8	0.004	0.092	0.015	0.024	0.011	0.489
M9	0.005	0.100	0.013	0.026	0.012	0.703
M10	0.004	0.084	0.014	0.020	0.014	0.428
M11	0.005	0.085	0.016	0.025	0.019	0.620
M12	0.004	0.091	0.015	0.024	0.017	0.530
M13	0.004	0.073	0.037	0.022	0.018	0.468
M14	0.005	0.093	0.013	0.021	0.016	0.230
M15	0.004	0.082	0.014	0.022	0.017	0.236
M16	0.822	0.106	0.014	0.026	0.017	0.399
M17	0.004	0.085	0.013	0.021	0.023	0.200
m18	0.003	0.073	0.019	0.017	0.014	0.248
M19	0.005	0.109	0.016	0.024	0.012	0.186
M20	0.003	0.094	0.014	0.023	0.013	0.210
M21	0.005	0.101	0.018	0.028	0.014	0.145
M22	0.006	0.065	0.012	0.023	0.016	0.213
M23	0.006	0.085	0.022	0.026	0.015	0.164
M24	0.003	0.080	0.014	0.020	0.013	0.297
M25	0.004	0.088	0.019	0.026	0.017	0.135
M26	0.007	0.099	0.025	0.021	0.013	0.239
M27	0.004	0.088	0.019	0.023	0.018	0.146
M28	0.004	0.118	0.018	0.022	0.016	0.570
M29	0.005	0.074	0.014	0.019	0.017	0.089
M30	0.004	0.064	0.013	0.020	0.018	0.172
M32	0.006	0.057	0.013	0.017	0.016	0.106
M33	0.004	0.062	0.015	0.023	0.014	0.122
M33	0.005	0.050	0.014	0.020	0.019	0.090
M34	0.006	0.097	0.015	0.024	0.019	0.098
M35	0.005	0.081	0.017	0.025	0.018	0.101
M36	0.004	0.089	0.015	0.022	0.021	0.102
M37	0.006	0.047	0.014	0.020	0.017	0.098
M38	0.005	0.068	0.017	0.024	0.018	0.099

Table (6): Annual average values of some heavy metals concentration in water samples from drains and mixed canals of Western Delta.

Code No.	(mg/L) Cd	Pb	Co	Ni	Cr	B
W1	0.004	0.048	0.014	0.022	0.019	0.187
W2	0.004	0.059	0.016	0.018	0.018	0.156
W3	0.005	0.049	0.022	0.017	0.020	0.161
W4	0.003	0.050	0.012	0.015	0.018	0.181
W5	0.003	0.076	0.013	0.015	0.017	0.151
W6	0.003	0.061	0.013	0.023	0.018	0.123
W7	0.002	0.072	0.010	0.016	0.015	0.162
W8	0.003	0.073	0.012	0.020	0.018	0.285
W9	0.004	0.071	0.010	0.014	0.020	0.296
W10	0.004	0.061	0.009	0.016	0.020	0.275
W11	0.006	0.072	0.017	0.016	0.019	0.689
W12	0.004	0.062	0.017	0.019	0.019	0.356
W13	0.003	0.071	0.012	0.021	0.021	0.283
W14	0.004	0.062	0.017	0.021	0.017	0.630
W15	0.004	0.050	0.017	0.020	0.018	0.396
W16	0.004	0.055	0.013	0.019	0.018	0.913
W17	0.003	0.029	0.014	0.022	0.020	0.724
W18	0.007	0.065	0.013	0.023	0.018	1.694
W19	0.003	0.089	0.014	0.020	0.014	1.170
W20	0.003	0.066	0.015	0.023	0.022	0.415
W21	0.005	0.059	0.012	0.025	0.017	1.448
W22	0.004	0.064	0.011	0.014	0.016	0.275
W23	0.004	0.077	0.016	0.017	0.018	0.120
W24	0.004	0.053	0.013	0.015	0.018	0.125
W25	0.004	0.062	0.015	0.018	0.019	0.102
W26	0.004	0.058	0.011	0.018	0.019	0.086
W27	0.004	0.036	0.009	0.019	0.020	0.094
W28	0.003	0.046	0.013	0.023	0.015	0.098
W29	0.003	0.050	0.012	0.021	0.017	0.095
W30	0.004	0.063	0.013	0.017	0.016	0.096

Table (6): Cont.

Code No.	(mg/L)					
	Cd	Pb	Co	Ni	Cr	B
N1	0.009	0.072	0.016	0.013	0.021	1.814
N2	0.007	0.060	0.013	0.013	0.021	1.794
N3	0.006	0.060	0.014	0.016	0.017	1.716
N4	0.006	0.067	0.024	0.017	0.022	1.709
N5	0.006	0.066	0.017	0.014	0.017	2.408
N6	0.005	0.065	0.008	0.016	0.016	1.784
N7	0.006	0.065	0.015	0.019	0.018	2.524
N8	0.007	0.097	0.016	0.013	0.018	1.449
N9	0.005	0.067	0.011	0.015	0.017	0.483
N10	0.005	0.082	0.013	0.008	0.023	2.669
N11	0.004	0.010	0.008	0.004	0.014	1.537
N12	0.006	0.087	0.009	0.020	0.018	0.623
N13	0.006	0.041	0.013	0.020	0.014	0.240
N14	0.006	0.077	0.012	0.016	0.015	0.316
N15	0.005	0.075	0.009	0.020	0.015	0.370
N16	0.005	0.069	0.015	0.017	0.017	0.391
N17	0.005	0.062	0.013	0.015	0.022	1.633
N18	0.005	0.096	0.015	0.011	0.024	1.006
N19	0.005	0.054	0.017	0.014	0.020	1.682
N20	0.005	0.081	0.013	0.013	0.015	0.173
N21	0.004	0.057	0.015	0.014	0.016	0.498
N22	0.004	0.051	0.022	0.015	0.015	0.346
N23	0.003	0.078	0.014	0.017	0.015	1.102

CONCLUSION

Using controlled soil drainage condition, water management and efficient use of N-Fertilizer are important for reuse drainage water in irrigation purposes. Boron may be toxic to sensitive crops which have potential health risks to human and animals. This is caused by Boron originating from discharges of household synthetic detergents or from industrial plants in these areas. Therefore, not all trace elements are toxic, in small quantities many are essential for plant growth (Fe, Mn, Zn, Cu and Mo). However, excessive quantities will cause undesirable accumulation in plant tissue and growth reduction. Heavy metals (Ni, Pb, Co, Cd, Cr) can pose significant health hazards to humans and animals and affecting the irrigated crops. These metals, in most cases, are accumulated in the plants. Therefore, many precautions need to be taken into consideration to control the uptake and accumulation of these metals by grown crops such that (control drains, maintain soil pH and organic matter). Treatment of pollution sources before draining into water ways is important.

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الملخص العربى

التقييم البيئى لمياه المصارف فى دلتا النيل لتحقيق التنمية الزراعية المستدامة:

ب- خطورة بعض العناصر

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تمت هذه الدراسة لتقييم نوعية مياه مصارف الدلتا التى تستخدم فى الرى من حيث احتوائها على بعض العناصر (N, ,P, Zn, Fe, Mn, Cu, Co, Cd, Ni, Cr and B). حيث أخذت عينات من مياه المصارف وكذا الترع المخلوطة خلال الفترة من يونيو ١٩٩٩ وحتى مايو ٢٠٠٠ من منطقة شرق ووسط وغرب الدلتا وكانت النتائج المتحصل عليها:

- **فى شرق الدلتا**... تحتوى مياه المصارف أو الترع المخلوطة بمنطقتى بحر البقر وبحر حادوس على تركيز من العناصر المختبرة (N,, P, Zn, Fe, Mn, Cu, Co, Cd, Ni, Cr and B) تحت الحدود المسموح بها فيما عدا ٢٠% ، ١٥%، ١٥% من عينات مياه مصارف بحر البقر تحتوى على تركيز مرتفع من البورون والمنجنيز والأمونيا على التوالى، وتزيد عن الحدود المسموح بها.
- **فى وسط الدلتا**... وجدت جميع العناصر المختبرة فى عينات مياه المصارف وكذلك الترع المخلوطة تحتوى على تركيزات فى الحدود المسموح بها.
- **فى غرب الدلتا**... وجدت جميع العناصر المختبرة لجميع عينات المياه تحتوى على تركيزات منها فى حدود التركيزات المسموح بها فيما عدا ٢١,٧% من عينات مياه المصارف تحتوى على تركيز مرتفع من البورون يزيد عن الحدود المسموح بها حيث صنفت من خفيفة إلى متوسطة. كما وجد أن ٥٤,٣% تحتوى على تركيز من الأمونيا يزيد عن الحدود المسموح بها وصنفت من خفيفة إلى متوسطة.

Environmental Assessment of Drainage Water in Nile Delta for Sustainable Agricultural Development: III- Public Health Hazard.

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ABSTRACT

This study were carried out to assess the drainage water quality for reusing in irrigation. Samples of drainage water (each represent drain or canal) were taken monthly during the period from June, 1999 to May, 2000 for Nile Delta region. The results indicated that:

- In Eastern Delta, all collected samples from Bahr El-Baqr drain area, 23.1% of total samples of Bahr Hadus area, and mixing canals are polluted with Faecal Coliform bacteria, the number of cells exceed the critical limits (more than 1000 cell/100 ml.).
- In Middle Delta, a 64.0% of the total collected samples contain high concentration of Faecal Coliform bacteria and exceed the critical limits, as well as irrigation canals which mixing with these drains.
- In Western Delta, a 47.8% of the total collected samples contain high concentration of Faecal Coliform bacteria and exceed the critical limits, as well as irrigation canals which mixing with these drains.
- Salmonilla and Shigella bacteria didn't detected in all the collected samples of the three parts of Nile Delta.

Therefore,, the most significant polluted drains discharged to the drainage network namely, Belbies - El-Qalubia-Bahr El-Baqr-Bahr Facous- El-Nizam drains at Eastern Delta, El- Sagaiya- Samatay- No. 5 - El-Gharbia - No. 6 - Toukh drains at Middle Delta, and Etay El-Baroud - El-Khandak El-Gharbi - El-Khairy-El-Dushudy at Western Delta, should be carefully examined. Treatment before discharging to the drains should be provided.

Keywords: Environment, drainage, irrigation, quality, pathogenic.

INTRODUCTION

Handling wastes of type in Egypt has been mainly concerned with moving it away from the source through public sewers, drains, the Nile and connected canals and eventually directly or indirectly into the Mediterranean sea and Northern lakes. Reuse of this water without pretreatment or any other controls of wastes, will lead to serious health risks. The potential risk of infection to humans, animals and plants from land application of reuse of drainage water is attributable to the presence of pathogenic organisms.

It is clear from many studies to date that, under favorable conditions, enteric pathogens can survive for extremely long periods of

It is clear from many studies to date that, under favorable conditions, enteric pathogens can survive for extremely long periods of time on crops, in water or in the soil (Feachem et al., 1983) and (Gerba et al., 1975). Ali et al. (1994) found at Bahr El-Baqr drain water and canal blending with these drain water were contaminated with high pathogens indicators which are Total Coliform and Faecal Coliform, while Salmonella and Shigella were not detected. They add that BOD and COD increased also as well as Total suspended solids, dissolved solids and exceed the critical limits. El-Wakeel and El-Mowehli (1990) reported from a study of drainage water in Middle Delta that the most significant and potential dangerous pollution impact was aggravated in Drain No.7 down- stream the outlet of Kafr El-Shaikh wastes; El-Gharbi El-Raisi along it is course up to El-Hamul village; Drain No.2, 3-km. down-stream of Belqas drain outlet, upper drain No.1 and Sabal drain. El-Mowelhi et al. (1995) reported that the most significant polluted drains were El-Dushudy,El-Qalaa, El-Tabia, El-Max, El-Khairy and Zarqun at Western Delta. On health aspects of use drainage water for agriculture, a recommended limits established by the Egyptian Decree No. 16 of law 93/1962 recommended by Committee (1995), and WHO (1989).

The ultimate goal of this study is to obtain accurate information related to the quality of drainage water at strategic locations along the main drains in the Nile Delta where significant changes of public health hazard were occurred due to the addition to or withdrawal from the drain

MATERIALS AND METHODS

To assess the drainage water quality for reusing in irrigation, samples of drainage water (each represent drain or canal) were collected monthly during the period from June, 1999 to May, 2000 for Nile Delta region.

The samples were analyzed immediately including;

- Pathogenic indicators (Total Coliform, Faecal Coliform, Salmonella and Shigella) were determined according to the methods described by Mahmoud (1988).
- Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), according to the method described in APHA (1992).

The main parts of Nile Delta drains were divided the region to East, Middle and West. These are:

1- Eastern Delta drains:

Code No.	Drain name	Code No.	Drain name
E1	El-Qalubia	E25	El-Wadi El-Sharqi canal "after" mixing
E2	Belbies	E26	Abu El-Akhder canal "before"
E3	Bahr El-Baqr inlet	E27	Abu El Akhder canal"after"
E4	Blad El-Ayed	E28	El-Salam at Sahret B. El-Baqr km 70
E5	El-Arin	E29	El-Serw Al-Alaa
E6	El-Saada	E30	Farskur
E7	Qahbuna	E31	El-Serw Al-Asfal
E8	Bahr El-Baqr 1	E32	El-Matana
E9	Bahr El-Baqr 2	E33	Omoum El-Behira Al-Asfal
E10	Ganub Port Said	E34	Omoum El-Behira Al-Alaa
E11	Ganub El-Hessania	E35	El-Fanan
E12	Bahr El-Baqr outlet	E36	El-Qasabi
E13	Shamal Ismalia	E37	Bahr Facous
E14	El-Mahsama	E38	Saft El-Qebli
E15	El-Manief	E39	Zarfodaki
E16	El-Wadi	E40	El-Nizam
E17	Gabal Mariem	E41	El-Senblawin
E18	El-Malana 1	E42	Bahr Hadus "outlet"
E19	El-Malana 2	E43	Nile at Damyiata "before"
E20	El-Ganien El-Bahri	E44	Nile at Damyiata "after"
E21	El-Ganien El-Qebli	E45	Hanut canal "before"
E22	Genifa	E46	Hanut canal "after"
E23	Shandura	E47	Dafan canal "before"
E24	El-Wadi El-Sharqi canal "before" mixing	E48	Dafan canal "after"

2- Middle Delta drains:

Code No.	Drain name	Code No.	Drain name
M1	El-Sagaiya	M20	El-Mandura
M2	Samatay	M21	Tala
M3	No. 5	M22	Sabal
M4	Ibshan	M23	El-Qarnien
M5	El-Gharbia	M24	No. 2
M6	No. 4	M25	Toukh
M7	No. 3	M26	No. 1
M8	No. 5	M27	El-Nasria
M9	El-Brolus	M28	El-Senanya
M10	El-Gharbia "outlet"	M29	Tira canal "before"
M11	Hafir Shehab El-Deen	M30	Tira canal "after"
M12	No. 7 Al-Asfal	M31	Tala canal "before"
M13	No. 8 Al-Asfal	M32	Tala canal "after"
M14	No. 9	M33	Mit Yazid canal "before"
M15	No. 9 "outlet"	M34	Mit Yazid canal "after"
M16	El-Zieni	M35	El-Riah Al-Abass "before"
M17	No. 11	M36	El-Riah Al-Abass "after"
M18	Mohit Zaghloul	M37	Nile at El-Mahllah "before"
M19	Nashart	M38	Nile at El-Mahllah "after"

3- Western Delta drains:

Code No.	Drain name	Code No.	Drain name
W1	Etay El-Baroud	N1	No 1
W2	Beshara	N2	No. 3
W3	Zarqun	N3	West Nubaria Drain "inlet"
W4	Idko Irrig.	N4	No 6
W5	El-Dilingat	N5	Koubri Massoud
W6	El-Khandak El-Gharbi	N6	El-Houria El-Nour
W7	El-Khairy	N7	El-Nour
W8	Halq El-Gamal	N8	El-Tahrir
W9	El-Qusor	N9	El-Omoum, Mariut
W10	El-Bousily	N10	West Nubaria "outlet"
W11	Mohit Idko	N11	West Nubaria (km 21)
W12	El-Tabia	N12	El-Boustan
W13	Idko "outlet"	N13	El-Nubaria canal "before" (km 29)
W14	El-Shershra	N14	El-Nubaria canal "after" (km 29)
W15	Abu Humos	N15	El-Nubaria canal "before" (km 86)
W16	Truga	N16	El-Nubaria canal"after" (km 86)
W17	El-Dushudy	N17	Oil waste company
W18	Hares	N18	Navigation canal of El-Nubaria "before"
W19	Abies	N19	Navigation canal of El-Nubaria "after"
W20	El-Qalaa	N20	El-Nubaria canal "before" (km 54)
W21	El-Omoum, Max	N21	El-Nubaria canal "after" (km 54)
W22	Bourg Rashid	N22	El-Nubaria canal "before" (km 55)
W23	El-Khandak El-Sharqi canal "before"	N23	El-Nubaria canal "after" (km 55)
W24	El-Khandak El-Sharqi canal "after"		
W25	El-Hager & Frhash canal "before"		
W26	El-Hager & Frhash canal "after"		
W27	Abu Diab canal "before"		
W28	Abu Diab canal "after"		
W29	El-Mahmudia canal "before"		
W30	El-Mahmudia canal "after"		

RESULTS AND DISCUSSIONS

Data presented in Tables (1, 2 and 3) and illustrated in Fig. (1) show the yearly average of pathogenic indicators (Total Coliform, Faecal Coliform, and Salmonilla and Shigella) and Chemical Oxygen Demand (COD) and Total Suspended Solids for drains water of Nile Delta.

a- Eastern Delta:

- **Bahr El-Baqr area**

It is noticed from the obtained data that, the concentration of Faecal Coliform bacteria are ranged from 133 to 933 × 10^2 cell/100 ml., 333 to 2033 × 10^2 cell/100 ml. for Total Coliform, 16 to 59 mg/L

Table (1): Annual average values of pathogenic indicators and some biological parameters in water samples from drains and mixed canals of Eastern Delta.

Location	Code No.	Total Suspended Solid (mg/L)	COD (mg/L)	Faecal Coliform	Total Coliform	Salmonilla & Shigella
				X 10^2 cell/100 ml		
Bahr El-Bagar area	E1	63	36	320	1033	nd*
	E2	196	21	633	890	nd
	E3	143	36	700	660	nd
	E4	164	18	233	600	nd
	E5	169	16	167	333	nd
	E6	69	22	267	440	nd
	E7	56	31	133	467	nd
	E8	195	30	300	967	nd
	E9	196	33	300	2033	nd
	E10	78	32	133	433	nd
	E11	38	37	133	1067	nd
	E12	206	59	200	967	nd
	E13	231	22	167	667	nd
	E14	56	19	233	1100	nd
	E15	64	22	233	500	nd
	E16	51	20	500	1500	nd
	E17	189	20	600	1000	nd
	E18	58	20	933	1833	nd
	E19	190	21	333	1700	nd
	E20	183	19	300	800	nd
	E21	171	18	300	1867	nd
	E22	223	24	200	1000	nd
	E23	232	29	367	1200	nd
	E24	198	28	222	767	nd
	E25	203	30	174	856	nd
	E26	201	24	158	885	nd
	E27	209	25	419	2362	nd
	E28	214	25	273	1421	nd
Bahr Hadus are	E29	52	38	5	28	nd
	E30	52	37	7	47	nd
	E31	56	28	12	37	nd
	E32	82	46	9	20	nd
	E33	62	34	12	64	nd
	E34	74	57	3	13	nd
	E35	53	37	3	16	nd
	E36	62	38	6	15	nd
	E37	64	35	22	18	nd
	E38	42	24	14	15	nd
	E39	35	30	5	24	nd
	E40	99	30	28	440	nd
	E41	50	33	6	17	nd
	E42	54	37	4	12	nd
	E43	50	39	14	32	nd
	E44	44	40	25	35	nd
	E45	45	35	5	10	nd
	E46	47	39	10	18	nd
	E47	76	40	8	10	nd
	E48	169	44	17	20	nd

* nd = Not detected.

Table (2): Annual average values of pathogenic indicators and some biological parameters in water samples from drains and mixed canals of Middle Delta.

Code No.	Total Suspended Solid (mg/L)	COD (mg/L)	Faecal Coliform	Total Coliform	Salmonilla & Shigella
			X 10^2 cell/100 ml		
M1	69	27	50	100	nd*
M2	80	23	57	154	nd
M3	120	23	48	141	nd
M4	98	27	48	80	nd
M5	86	30	28	50	nd
M6	60	29	23	45	nd
M7	88	31	13	61	nd
M8	148	40	12	44	nd
M9	115	35	9	27	nd
M10	112	27	15	30	nd
M11	117	26	21	59	nd
M12	129	29	15	95	nd
M13	127	33	17	59	nd
M14	74	26	25	78	nd
M15	71	24	14	50	nd
M16	82	31	3	38	nd
M17	81	32	3	17	nd
M19	50	31	17	47	nd
M20	47	29	26	65	nd
M21	93	21	18	63	nd
M22	128	40	18	101	nd
M23	61	22	26	83	nd
M24	63	38	5	20	nd
M25	46	24	26	99	nd
M26	49	26	34	18	nd
M27	55	35	5	16	nd
M28	152	55	11	35	nd
M29	41	23	8	20	nd
M30	38	27	28	57	nd
M31	71	29	6	27	nd
M32	48	26	10	35	nd
M33	57	21	3	7	nd
M34	38	19	4	11	nd
M35	41	24	8	19	nd
M36	37	21	12	22	nd
M37	27	21	7	16	nd
M38	45	23	7	14	nd

* nd = Not detected.

Table (3): Annual average values of pathogenic indicators and some biological parameters in water samples from drains and mixed canals of Western Delta.

Code No	Total Suspended Solid (mg/L)	COD (mg/L)	Faecal Coliform	Total Coliform	Salmonilla & Shigella
			X 10^2 cell/100 ml		
W1	94	21	24	44	nd*
W2	110	20	5	22	nd
W3	59	23	6	33	nd
W4	93	21	20	44	nd
W5	52	22	8	29	nd
W6	42	21	27	29	nd
W7	64	21	24	59	nd
W8	110	25	4	28	nd
W9	146	27	5	33	nd
W10	89	21	14	39	nd
W11	93	18	17	57	nd
W12	89	24	20	52	nd
W13	89	21	6	32	nd
W14	50	19	11	24	nd
W15	93	21	8	25	nd
W16	96	19	12	30	nd
W17	109	23	18	54	nd
W18	109	31	14	29	nd
W19	102	29	18	43	nd
W20	56	24	19	40	nd
W21	88	24	24	54	nd
W22	89	30	7	35	nd
W23	89	25	4	19	nd
W24	72	26	17	31	nd
W25	47	25	2	4	nd
W26	74	33	3	15	nd
W27	115	28	2	7	nd
W28	66	28	15	54	nd
W29	48	25	12	40	nd
W30	54	31	17	28	nd

* nd = Not detected.

Fig. (1): Pathogenic indicators (Faecal Coliform) in drain water of drainage catchment areas in the Nile Delta.

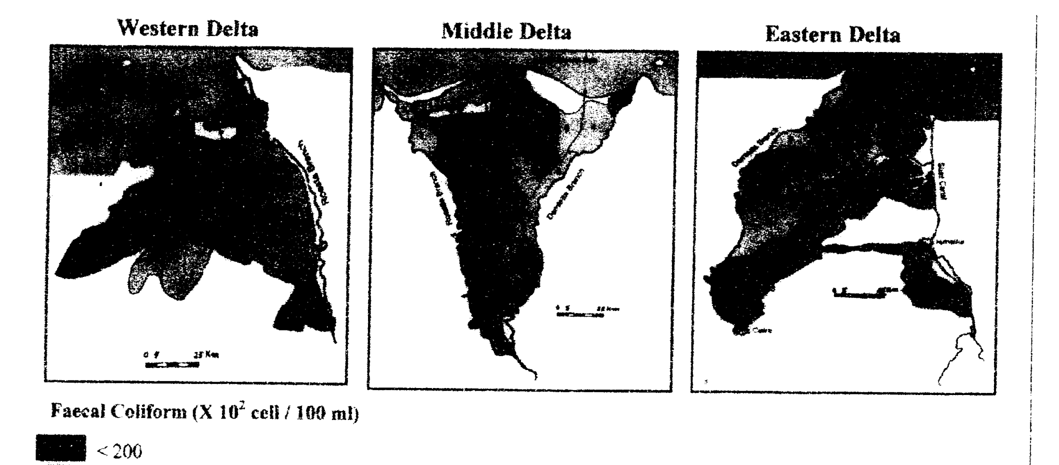


Fig. (1): Pathogenic indicators (Faecal Coliform) in drain water of drainage catchment areas in the Nile Delta.

for COD and 51 to 232 mg/L for suspended solid. Salmonella and Shigella bacteria are not detected.

It could be concluded that all drains as well as mixing canals with drainage water (El-Wadi El-Sharqi and Abu E-Akhader) are polluted with Faecal Coliform and Total Coliform bacteria and exceed the critical limits (more than 1000 cell/100 ml.) according to the guidelines recommended by Egyptian committee in Decree 16 of Law 93/19962 (1995) and WHO (1989). Therefore, risk due to health hazard of the degree of restriction in use for irrigation. COD is found in low concentration (Less than 40 mg/l) in all drains except Bahr El-Baqr outlet which is reached 59 mg/l. Whereas, suspended soils were found in high concentration and exceed the critical limilts (more than 40 mg/l).

- **Bahr Hadus area**

It is noticed from the obtained data that the concentration of Faecal Coliform bacteria are ranged from 3 to 28 $\times$ 10^2 cell/100 ml, 12 to 440$\times$$10^2$ cell/100 ml. for the Total Coliform, 24 to 57 mg/l for COD, and 35 to 99 mg/l for Suspended solids. Salmonella and Shigella are not detected.

It could be concluded that 30.7% of the total Samples of drains and all samples of mixing canals were polluted with Faecal Coliform as well as Total Coliform and exceed the critical limits. El-Nizam drain is the highest polluted drain which has 28 and 440$\times$$10^2$ cell /100 ml. For Faecal Coliform and Total Coliform, respectively. The mixing canals (Nile at Damiatta, Hanut and Dafan) are polluted with Faecal Coliform after mixing with E-Serw Al-Asfal (1200 cell/100 ml.); Saft El-Qebli (1400 cell/100 ml.) and Bahr Facous (22 cell/100 ml.) drains, respectively. It ranged from (1400 to 2500) , (500 to 1000) and (800-1700) cell/100 ml before and after mixing with these drains COD is found in low concentration except Omoum El-Beheira El-Alaa that has 57 mg/l. The suspended solids are found in high concentration. Salmonilla and Shigella didn't detected.

Concerning El-Salam Canal, it is polluted with Faecal Coliform bacteria. The yearly average at the site of Saharet Bahr El-Baqr (km 70) reached 273 $\times$ 10^2 cell/100 ml., where El-Serw Al-Asfal drain at (k m 17.5) is (12$\times$$10^2$ cell/100 ml.) and Bahr Hadus "outlet" drain at (Km 42) is (4$\times$$10^2$ cell/100 ml.). This may be led to find out the sources of pollution of El-Salam canal through its length.

Thus, to protect public health; monitoring and treatment should be examined to the most significant polluted drains, which discharged to the drainage network namely Belbies, El-Qalubia, Bahr El-Baqr, El-Nizam, and Bahr Facous drains.

b- Middle Delta:

It is noticed from the obtained data that the concentration of Faecal Coliform bacteria are ranged from 3 to 57×10^2 cell/100 ml., 16 to 154×10^2 cell/100 ml. for Total Coliform, 21 to 40 mg/l for COD and 46 to 148 mg/l for Total Suspended Solids. Salmonella and Shigella bacteria are not detected.

It could be concluded that most of the drains (88% of the total samples) were polluted with Faecal Coliform as well as Total Coliform bacteria and exceed the critical limits. COD is found in low concentration in all drains, whereas, Total Suspended solid were found in high concentration and exceed the critical limits.

It is noticed that all mixing canals have low concentration of Faecal Coliform bacteria except Bahr Tira and El-Riah El-Abassi canals which have high concentration after mixing with drains water and exceeded the critical limits. It ranged from 8 to 28 and 8 to 12×10^2 cell/100 ml., respectively. This is mainly due to high concentration of pollution of El-Gharbia (28×10^2) and El-Qarnien drains (26×10^2) cell/100 ml.

Thus to protect the public health monotring and treatment should be examined carefully to the most significant polluted drains which discharged to the drainage network namely, El-Sagaiya, Samatay, No.5 , No.6 , El-Gharbia , No.1, and Toukh drains.

C. Western Delta

It is noticed from the obtained data that the concentration of Faecal Coliform bacteria are ranged from 4 to 27×10^2 cell/100 ml., 42 to 59×10^2 cell/100 ml for Total Coliforms, 19 to 30 mg/l for COD and 42 to 146 mg/l for Total Suspended Solids. Salmonella and Shigella bacteria weren't detected.

It could be concluded that most of drains (47.8% of the total samples) were polluted with Faecal Coliform as well as Total Coliform bacteria and exceeded the critical limits. COD is found in low concentration in all drains. Whereas, Total Suspended Solids are found in low concentration and exceeded the critical limits.

It is noticed that West Nubaria drain is polluted where all drains discharged in have high pollution. It has high concentration of Faecal Coliform and exceed the criticl limits. Their average values were 10 at the beginning of West Nubaria drain at Ganakils, 20, 11, 15, 23, 26 $X10^2$ cell/100 ml for drain No.6, Koubri Masoud, El-Houria, El-Nour and El-Tahrir drains, respectively. It reached 20 $X10^2$ cell/100ml.at the outlet of West Nubaria drain at Hawis El-Nahda.

It is noticed that mixing El-Nubaria canal are polluted with Faecal Coliform bacteria and exceed the criticl limits. It ranged before and after mixing from 9-13 to 15-32 $\times10^2$ Cell /100 ml., respectively. This is mainly due to the concentration of drainage water of drains No.1 at km

54. (19×10^2 cell/100 ml.) and No.3 at km 55 (14×10^2 cell/100 ml.) at Ganaklis area.

On the other hand, at mixing location of El-Boustan drain at km 29 and El-Omoum drain at km 86, are polluted with Faecal Coliform bacteria but the concentration is still below the criticl limits. It ranged before and after mixing in these drains, from 500 to 700 and 800 to 900 cell / 100 ml., respectively.

El-Khandak El-Shaqi, Abu Diab and El-Mahmoudia canals, the Faecal Coliform bacteria were higher and exceed the criticl limits after mixing with Etay El-Baroud (2400 cell/100 ml.), El-Khandak El-Gharbi (2700 cell/100 ml) and Edko irrigation (2000 cell/100 ml.) respectively. Their concentration were reached before and after mixing (400 to 1700) and (200 to 1500) cell / 100 ml.(1200-1700 cell/100ml). El-Hager canal is below the critical limits, it ranged from 200 to 300 cell / 100 ml. because it was mixed with El-Dilingat drain (800 cell /100 ml.).

It is noticed that oil waste companies discharged wastes to Nubaria canal at Navigation canal. Therefore, Faecal Coliform bacteria increased and exceeded the critical limits, it reached before and after mixing from 700 to 1100 cell / 100 ml. where the concentration in the wastes of the company was 1800 cell/100 ml.

It could be concluded that the most significant polluted drains in Western Delta which discharged to the drainage water network namely, Etay El-Baroud El-Khandak El-Gharbi, El-Khairy, El-Qalaa and El-Dushudy, should be examined and treated carefully.

CONCLUSION

To protect public health the effluent should either be properly treated before discharged to the drainage network and reuse for irrigation application, or its use in restriction to certain crops which do not reach any part of a plant used for human or animal consumption.

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التقييم البيئى لمياه المصارف فى دلتا النيل لتحقيق التنمية الزراعية المستدامة:
ج- الصحة العامة

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الملخص العربى

تمت هذه الدراسة لتقييم نوعية مياه مصارف الدلتا التى تستخدم فى الرى من حيث احتوائهـا على بكتريا القولون البرازية والكلية والأكسجين الكيماوى الممتص وبكتريـا السـالمونيا والشـيجلا وكمية المواد العالقة. حيث أخذت عينات من مياه المصارف وكذا الترع المخلوطة خلال الفترة مـن يونيو ١٩٩٩ وحتى مايو ٢٠٠٠ من منطقة شرق ووسط وغرب الدلتا وكانـت النتـائج المتحصـل عليها:

- **فى شرق الدلتا**... تحتوى عينات مصارف منطقة بحـر البقـر ، ٢٣,١% مـن عينـات ميـاه مصارف منطقه بحر حادوس وكذلك الترع المخلوطة من هذه المصارف على تركيز مرتفع مـن بكتريا القولون البرازية وهى تزيد عن الحدود المسموح بها (أكثر من ١٠٠٠ خلية/١٠٠مل).
- **فى وسط الدلتا**... تحتوى ٦٤% من عينات مياه المصارف على تركيـز مرتفـع مـن بكتريـا القولون البرازية وهى تزيد عن الحدود المسموح بها وبالمثل كانت الترع المخلوطـة مـن هـذه المصارف.
- **فى غرب الدلتا**... تحتوى ٤٧,٨% من عينات مصارف غرب الدلتا على تركيـز مرتفـع مـن بكتريا القولون البرازية وتزيد عن الحدود المسموح بها وبالمثـل التـرع المخلوطـة مـن هـذه المصارف.
- لم تشاهد بكتريا السالمونيلا والشيجلا فى جميع العينات المختبرة من مصارف الدلتا.
- وبناء عليه يعتبر العامل المحدد لإستخدام هذه المياه هو التلوث بالميكروبات الممرضـة ولـذلك يجب تحليل ومعالجه مياه المصارف الملوثة قبل صرفها فى شبكه المصارف الزراعيـة وهـى مصارف بلبيس - القليوبيه - بحر البقر - بحر فـاقوس - النظـام بمنطقـه شـرق الـدلتا - والسجاعيه - سماتاى - نمره ٥ - الغربيه - نمره ١ - طوخ - نمره ٦ بمنطقه وسـط الـدلتا، إيتاى البارود - الخندق الغربى - الخيرى - القلعه - الدشودى بغرب الدلتا.

Techniques Effect of Phosphorus Fertilization on Zinc Uptake in Wheat Plants "Triticum aestivum" at Different Growth Stages and Availability in Soil .

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ABSTRACT

To study the techniques effect of phosphorus fertilization on zinc uptake in wheat plants" Triticum aestivum" at different growth stages and availability in soil, four techniques of fertilization with P fertilizers (mixing the P fertilizer with seeds MD, broadcast on soil surface without mixing BR, broadcast on soil with mixing MX ,and localized in bands 5 cm below soil surface & 3 cm below seeds LC) two fertilizer sources (ordinary superphosphate OSP and triple super- Phosphate TSP), two forms (granulated G and powdered P) and three rates (10,20 and 40 mg P/kg soil). The experiment was conducted as pot experiment with three replicates using complete randomized design. Three sets of plant samples at 40 , 60 and 120 days after sowing were collected to carry the chemical analysis. After harvest soil samples were taken in three depths (0-10, 10-20 and 20-30 cm). Available Zn was determined in the soil samples. Generally, data show that effect of treatments on Zn-uptak, can be arrangement as follows: BR > Mx > Lc > Md, OSP > TSP, medium > Low > high , and G >P only at 40 day. However, effect of treatment on Zn-availability in soil can be arrangement as follows. BR = Mx > Lc=md

INTRODUCTION

One of the most important aspects of fertilizer usage is to know when fertilizers should be applied. Among various factors contributing to plant growth , nutrient availability plays a vital role, however, these may interact synergistically or antagonistically in soil, in plant or at absorption sites.

Results of Zn status in soils and Zn uptake are affected by P application, According to Tisdale and Nelson (1975) P depletion zones arround deep plant roots is affected by pH changes in the rhizosphere. If the phosphate particles are exposed to a greater amount of surface, more fixation tokes place than if the same amount of fertilizer had been applied in bands. Band placement reduces the surface of contact between the soil and fertilizer, thas reducing P-fixation and increasing plant utilization. Salam et al.(1978) reported that in a field of very coarse sand soil under irrigated wheat the top 20-cm surface contained 40 mg p/kg, whereas the immediate underlying 20-cm layer contained less than 3 mg P/ Kg. Roots grow better in the soil surrounding the row of fertilizers Gilis (1984) reported that rows of P- fertilizer become soon surrounded by thick nets of fine plant roots.

Supplying nutrients to the above ground plant parts giving high yields.

(Engelatad 1985, Sparrow et al.1993, White 1996 and Chigarev et al. 1997) Showed that banding P- Fertilizers gave greater yields of crops compared with broadcast, followed by mixing into the soil; the difference in efficiency between banded and broadcast applications of P materials is usually greater in soils of low available P. Selim et al.(1986)reported that mobility of p in the soil profile is comparatively low and the uptake of fertilizer P depends much on root growth and the root morphology of plant.

According to Mengel and Kirkby (1987) reported that the P-fertilizer is applied in the form of a band(Placed application) the extent of contact with soil particles is reduced and p fixation is thus reduced; and if the band is near the seed, a zone of high phosphate concentration is accessible to the growing plant roots.

Moursy (1995) found that coating maize seeds with ordinary superphosphate gave the highest yield per one kgP/ fed as compared with banding or broadcast methods. According to Hernandez et al. (1997) Obtained increased contents of available P in soil associated with increased application of fertilizer P (application of up to 173 kg P/ha).

Availability of Zn^{2+} to Plants depends on a number of soil and environmental factors, among various factor interactions with other nutrients. According to (Mandal and Haldar 1980, Megalah 1994) applied P fertilizer and found a decrease in DTPA- extractable Zn in soil.

(El-Kherbawy and Roger Sanders 1984 and Gupta et al.1985) showed that Zn concentration in clover shoots was significantly lower when plants were grown on soils of high P status. (Ismail et al.1986 and Gant and Bailey 1989) reported Zn uptake (Tomato) was decreased by the increased phosphorous application. According to Kaushik et al. (1995) showed that increasing P levels (0 to 120 mg P/kg soil) was associated with decreasing Zn uptake.

The aim of this study is to investigate the effect of some Techniques in application of P- fertilizers (mixing with seeds, broadcast on soil surface without mixing , mixing with the soil and localized in bands) on zinc uptake in wheat plants and availability in soil.

MATERIALS AND METHODS

A pot experiment was conducted in the Agricultural Research Station in Giza on wheat plants "Triticum aestivum" cv. Seds 1. Soil using a non saline sandy clay loam collected from one of the fields of the kerdasa, Giza.

The soil samples were analyzed mechanically to determine particle size distribution by the pipette Method (Piper 1950). Organic matter was determined according to the modified method of Walkley and Black and

calcium carbonate content was done using the calcimeter(Jackson 1963). Total salinity and soluble ions were detremined according to Richards 1954. Available P,K and micronutrients (Fe, Mn, Zn, Cu) were determined by extracting the soil with Ammonium Bicarbonate-DTPA (Soltanpour 1985). Tables 1 and 2 show properties of the soils and the P-fertilizers used in the experiment.

This investigation for studying the effect of 4 techniques of applying phosphate fertilizer (Broadcast {BR}, Mixing with soil {Mx}, localized in bands 5 cm below soil surface & 3cm below seeds {Lc} and mixing with seedes {Md}) "factor 1" using 2 fertilizer sources (ordinary super - phosphate { OSP} and triple superphosphate {TSP} "factor 2" in 2 Morphologic forms (Powdered with particles of < 0.25 mm Ø and Granulated with particles between 1 to 4 mm Ø "factor3" at three phosphorus rates (low : 10 mg P/kg soil, Medium : 20 mg P/kg soil and high : 40 mg p/kg soil) "factor4" . Besides there was a treatment where no fertilizer P was used "control". The various combinations of the 4-factors + the non – fertilized. The design was a complete randomized with 3 replicates. The soil samples were placed in plastic pots (20-cm Ø and 30-cm depth).Each pot contained 3kg of air-dry soil (< 1 cm Ø).All pots received K at a rate of 25 mg k/kg soil (as potassium sulphate 42% K) in concentrated water solution mixed thoroughly with soil material at the beginning of preparation and before seeding. Also, the each pot received N at a rate of 75 mg N/kg soil (as ammonium nitrate, 33.5% N) in 2 splits : one third before seeding in solution mixed with soil; two thirds in a solution after 6 weeks of seeding. Each pot was provided with 10 seeds sown so as to be placed 2-cm below soil surface. All pots were irrigated with tap water. Soil moisture was kept at around 70-80% of the water holding capacity. Plant samples were taken at 40,60, and 120 days after sowing. Samples of plants were oven dried at 70c° and wet digestion with H_2SO_4 + $HClO_4$ and determination of Zinc was by using Atomic Absorption. Plant sample at 40 or 60 days consisted of one plant, measurement of Zinc uptake was expressed in wet pot by multiplying by 10 on the basis of 10 plant in the pot. After harvesting soil samples were taken at three depths(0-10, 10-20 and 20-30 cm). Available Zn was determined in the soil samples . The data were statistically analyzed according to (Steel and Torrie 1960)

Table (1) : Analysis of the sandy clay loam soil used in the experiment.

A. Chemical	
EC.dS/m (of paste extract)	2.59
Soluble ions (mmolc/L); in the paste extract	
Ca^{++}	15.68
Mg^{++}	6.36
Na^{+}	5.26
K^{+}	0.48
$CO_3^{=}$	0.00
HCO_3^{-}	4.50
Cl^{-}	10.11
$SO_4^{=}$	13.17
pH (Soil: water suspension 1:2.5)	7.99
Organic matter %	2.48
$CaCO_3$ %	2.77
Available nutrients (mg/kg)*	
P	4.6
K	143
Fe	13.7
Mn	18.2
Zn	2.00
Cu	7.00

B. Physical					
C.Sand%	F.Sand%	Silt%	Clay%	Texture	FC
37.2	18.5	10.8	33.5	Sandy clay loam	21.6
Saturation percentage				36.7%	

***Available nutrients all extracted by NH_4HCO_3 – DTPA(1:2 soil : extract ratio).**

Table (2): Analysis of the phosphorus fertilizer.

Sources	P %	P_2O_5 %
Ordinary superphosphate (OSP)	7.7	17.6
Triple superphosphate (TSP)	24.0	54.9

% P_2O_5 = %Px2.29

RESULTS AND DISCUSSIONS

Zinc uptake by wheat plants as affected by P-fertilization techniques after 40,60 and 120 day of sowing (Table 3).

P-fertilizer may be placed in the soil to raise soil fertility and increase crop yields , but the plants may become dificient in Zn, .Results concerning all parameters show a negative response to P-application as shown by comparison between the control (unfertilized) and the fertilized treatment. Discussion will be focused on effect of P-fertilization techniques on Zn-uptake in wheat plants and availability in soil .

1-Main effect of techniques(T) for the 40-day wheat growth :

Data of the zinc uptake after 40 days from sowing (Table 3) reveal that the nonfertilized plants showed 490.03 µg Zn/pot . The BR technique was superior to all other techniques giving a 481.17 µg Zn/pot followed by the Mx technique (422.56 µg Zn/pot), then by the Lc and Md techniques whereas, the Md technique and Lc technique gave the lowest Zn uptake 283.22 and 268.76 µg Zn/pot, respectively . The two latter techniques were similar.

Relevant significant interactions involving techniques :

- Technique and fertilizer source (TS) :

The BR technique remained the most superior with both sources, but the similarity of BR and Mx techniques (with both being superior to Lc and Md techniques occurred only where OSP was used . However , when TSP was used , Lc was inferior to Md , the treatments arrangement as follows :

BR > Mx > Md > Lc

- Technique and form (TF) :

The pattern of BR > Mx > Md > Lc occurred with each of powdered P-fertilizer and granulated. When granulated P-fertilizer Lc and Md techniques were alike Therefore, mixing P-fertilizer with seeds or localized technique, particularly when given as granulated, results in lower Zn-uptake.

- Technique and rate (TR) .

The BR technique gave highest values of Zn-uptake and followed by Mx under all rates. For the Lc and Md techniques, they were similar under 20 and 40 mg P/kg , but under 10 mg P/kg the Lc gave lower values than the Md technique .

II-Main effect of techniques (T) for the 60-day wheat growth .

Effect of P-fertilization techniques on Zn uptake in wheat plants after 60 days of sowing are presented in Table 3 . The unfertilized treatment showed 1940.1 µg Zn/pot. There were significant differences between techniques of application. The BR technique considerably surpassed all other techniques giving considerably more Zn-uptake (1839.19 µg Zn/pot) than other techniques ; followed by Mx technique (1652.50 µg Zn/pot) then by Lc (825.13 µg Zn/pot) and Md (750.70 µg Zn/pot.) Lc and Md techniques were similar in effect .

- Technique and fertilizer source (TS) .

The Mx technique was superior to the BR technique when the OSP source . When TSP source, the BR technique was superior to the Mx technique. The similarity of Lc and Md occurred with the OSP and TSP sources , thus giving lower Zn-uptake .

- Technique and form (TF) .

Data in Table 3 at 60-day growth show an interaction between the technique of P-fertilization and the form of P-fertilizer . With both forms BR gave the highest Zn-uptake , but the BR and Mx were similar in effect when the P-fertilizer was granulated . With both forms Lc and Md were alike , and the two gave lower Zn-uptake .

- Technique and rate (TR) .

The pattern of comparison of techniques was not the same in all rates of P . Under the low rate of 10 mg P/kg the pattern was BR = Mx > Lc = Md .Under the 20 mg P/kg , it was BR>Mx > Lc> Md . Under the high 40 mg P/kg , it was BR=Mx>Lc=Md . Thus the BR technique gave greater Zn-uptake , but Md technique gave lower Zn-uptake .

III-Main effect of techniques(T) for the 120- day wheat growth.

Table 3 at 120-day growth show a Zn-uptake of 3693.15 µg Zn/pot for unfertilized pots . Effect of treatments show mean values of 3781.54 , 3675.24 , 1879.85 , 1217.16 µg Zn/pot for BR,Mx,Lc,Md , giving a pattern of BR=Mx>Lc=Md.

- **Conclusive assessment on the effect of techniques on Zn- uptake in wheat plants .**

Adding phosphate fertilizer mixied with seeds gave greater P-uptake followed by the localized placement. The broadcast techniques gave lower P-uptake followed by the mixing with soil , particularly when rates were low with powdered forms .The very high of available P with application of P by mixed with seeds , decrease contact between soil and fertilizer while increases contact between fertilizer and plant roots in the

area of the seeded seeds as compared with BR,Mx . Gilis (1984) observed more intensive root growth in the soil surrounding the row of P fertilizer and concluded that localized application of fertilizerP increases plant growth . Moursy (1995) reported that the localized application of P in bands was superior to broadcast with mixing . Zn-uptake deficiency occurred with greater P-uptake , possibility a slower rate of translocation of Zn from the root to the tops or P-Zn antagonism within the roots . El-Kherbawy and Roger Sande (1984) showed that Zn concentrations in clover shoots was significantly lower when plants were grown on soils of high P status . Available Zn in soil of 1st layer (0-10 cm) , 2nd layer (10-20 cm) , and 3rd layer (20-30) after harvest . (Table 4) .

I-Main effect of techniques (T) of 1st layer:

Available Zn of unfertilized soil was 3.40 mg Zn/kg soil. Mean values of available Zn for the technique treatments were 3.02, 2.99 , 2.45 , and 2.34 for BR,Mx, Lc, and Md, respectively. From the statistical significance viewpoint, comparison of the techniques is as follows:

BR = Mx > Lc = Md . Thus , the difference between the BR and Mx was not significant , neither was the difference between Lc and Md . The former two techniques showed greater available over the latter two techniques .

II-Main effect of techniques (T) of 2nd layer :

Available Zn in the 2nd layer (10-20 Cm) was lower than the top layer . In the unfertilized. Treatment it was 3.20 mg Zn / kg soil . Mean values of available Zn for the technique treatments were 2.64 , 2.64 , 2.19 and 2.12 mg Zn/kg for BR, Mx, Lc and Md respectively . Such a pattern is identical to the pattern of response concerning available Zn in soil of 1st layer.

- Technique and fertilizer source (TS) .

Where the OSP source was used, the Mx technique showed more available Zn than Lc and Md techniques, where TSP source was used the treatments arrangement as follows : BR > Mx > Lc = Md .

Table (3) Effect of some techniques of fertilization with P fertilizer on wheat plants uptake of Zn (μg Zn/pot) after 40, 60 and 120 day after sowing

Phosphorus treatments			Techniques of fertilization														
Source (S)	Form (F)	Rate(R) m/kg	BR	Mx	Lc	Md	mean	BR	Mx	Lc	Md	mean	BR	Mx	Lc	Md	mean
			μg Zn/pot after 40 day of sowing					μg Zn/pot after 60 day of sowing					μg Zn/pot after 120 day of sowing				
OSP	P	10	265.63	294.70	178.47	186.67	231.37	630.62	924.35	644.57	540.48	685.00	6173.07	5973.63	5987.03	1504.40	4909.53
		20	359.83	481.48	212.03	229.20	320.64	1004.43	1667.12	624.52	397.20	923.32	5161.97	4655.50	1724.20	1641.40	3295.77
		40	413.48	415.17	302.20	263.92	348.69	1691.67	1352.83	543.18	885.20	1118.22	6278.20	3674.77	2280.80	1837.77	3517.88
		Mean	346.32	397.12	230.90	226.59	300.23	1108.91	1314.77	604.09	607.63	908.85	5871.08	4767.97	3330.68	1661.19	3907.73
	G	10	443.83	396.57	292.63	315.70	362.18	1351.23	1043.40	789.08	668.50	963.05	4157.73	1993.33	2154.37	1546.73	2463.04
		20	721.65	646.58	414.78	348.03	533.26	2526.28	2269.53	1035.85	676.03	1626.93	2077.03	2692.80	1465.97	1209.00	1859.95
		40	499.73	461.20	347.13	318.15	406.55	1346.77	2516.47	866.53	655.17	1346.23	5549.03	8876.90	1538.70	1340.77	4326.35
		Mean	555.74	501.45	351.52	327.29	434.00	1741.43	1943.13	897.16	666.57	1312.07	3926.27	4521.01	1719.068	1365.50	2883.11
	Mean		451.03	449.28	291.21	276.94	367.12	1425.17	1628.95	750.62	637.10	1110.46	4898.67	4644.49	2525.18	1513.34	3395.42
TSP	P	10	658.60	390.15	265.70	350.95	416.35	1643.22	2097.13	792.37	810.85	1335.89	1452.00	2116.77	1419.60	1322.90	1577.82
		20	465.78	323.98	216.23	327.38	333.35	4789.10	1868.07	1043.42	581.65	2070.56	4820.63	3177.27	954.70	1031.97	2496.14
		40	437.5	377.60	278.72	311.82	351.43	2564.33	1676.25	1112.37	900.60	1963.39	3570.43	2782.10	1433.47	775.57	2140.39
		Mean	520.66	363.91	253.55	330.05	367.04	2998.88	1880.48	982.72	764.37	1656.61	3281.02	2692.04	1269.26	1043.48	2071.45
	G	10	435.43	441.38	271.23	296.13	361.05	2376.75	1477.78	837.63	1110.33	1450.63	2194.87	4483.10	867.67	824.80	2092.61
		20	659.40	578.97	229.23	181.00	412.15	1231.18	1911.93	978.68	902.23	1256.01	1251.07	1147.27	896.83	685.67	995.21
		40	411.08	263.00	216.80	269.63	290.13	914.67	1025.13	633.35	880.18	863.33	2697.43	2529.50	1834.87	884.93	1986.68
		Mean	501.97	427.78	239.09	248.92	354.44	1507.53	1471.62	816.56	964.25	1189.99	2047.79	2719.96	1199.79	798.47	1691.50
	Mean		511.31	395.85	246.32	289.49	360.74	2253.21	1676.05	899.64	864.31	1423.30	2664.41	2706.00	1234.52	920.97	1881.48
Mean			481.17	422.56	268.76	283.22	363.93	1839.19	1652.50	825.13	750.70	1266.88	3781.54	3675.24	1879.85	1217.16	2638.45
P		10	462.12	342.43	222.08	268.81	323.86	1136.92	1510.74	718.47	675.67	1010.45	3812.53	4045.20	3703.32	1413.65	3243.68
		20	412.81	402.73	214.13	278.29	326.99	2896.77	1767.59	833.97	489.43	1496.94	4991.30	3916.38	1339.45	1336.68	2895.95
		40	425.53	396.38	290.46	287.87	350.06	2128.00	1514.54	827.78	892.90	1340.80	4924.32	3228.43	1857.13	1306.67	2829.14
Mean			433.49	380.51	242.23	278.32	333.64	2053.59	1597.63	793.40	685.99	1282.73	4576.05	3730.01	2299.97	1352.33	2989.59
G		10	439.63	418.98	281.93	305.92	361.62	1863.99	1260.59	813.36	889.42	1206.84	3176.30	3238.22	1511.02	1185.77	2277.83
		20	691.53	612.78	322.01	264.52	472.71	1878.73	2090.73	1007.27	789.13	1441.47	1661.55	1920.03	1181.40	947.33	1427.58
		40	455.41	362.10	281.97	293.89	348.34	1130.72	1770.80	749.94	767.68	1104.78	4123.23	5703.20	1686.78	1112.85	3156.52
Mean			528.86	464.62	295.30	288.11	394.22	1624.48	1707.38	856.86	815.41	1251.03	2987.03	3620.48	1459.73	1081.98	2287.31
OSP		10	354.73	345.63	235.55	251.18	296.78	990.93	93.88	716.83	604.49	824.03	5165.40	3983.48	4070.70	1525.57	3686.29
		20	541.74	564.03	313.41	288.62	426.95	1765.36	1968.33	830.18	536.62	1275.12	3617.00	3674.15	1595.08	1425.20	2577.86
		40	456.61	438.18	324.67	291.05	377.62	1519.22	1934.65	704.86	770.18	1232.23	5913.62	6275.83	1909.75	1589.27	3922.12
TSP		10	547.02	415.77	268.47	323.54	388.70	2009.98	1787.46	815.00	960.39	1393.26	1823.45	3299.93	1143.63	1073.85	1835.21
		20	562.59	451.48	222.73	254.19	372.75	3010.14	1890.00	1011.05	741.94	1663.28	3035.85	2162.27	925.77	858.82	1745.68
		40	424.33	320.30	247.76	290.73	320.78	1739.50	1350.69	872.86	890.39	1213.36	3133.93	2655.80	1634.17	830.25	2063.54
Rate		10	450.88	380.70	252.01	287.36	342.74	1500.45	1385.67	765.91	782.54	1108.64	3494.42	3641.71	2607.17	1299.71	2760.75
		20	552.17	507.75	268.07	271.40	399.85	2387.75	1929.16	920.62	639.28	1469.20	3326.43	2918.21	1260.43	1142.01	2161.77
		40	440.47	379.24	286.21	290.88	349.20	1629.36	1642.67	788.86	830.29	1222.79	4523.78	4465.82	1771.96	1209.76	2992.83
Unfertilized (Control)			490.03					1940.10					3693.15				
LSD 5%			S=ns R=14.7 SFR=ns FT=23.9 SRT=41.5 F=11.9 SR=20.7 T=16.9 SFT=33.9 FRT=41.5 SF=16.9 FR=20.7 ST=23.9 RT=29.4 SFRT=58.7					S=94.8 R=116.1 SFR=232.2 FT=189.65 RT=328.4 F=ns SR=164.2 T=134.1 SFT=268.1 FRT=328.4 SF=134.1 FR=164.2 ST=189.6 RT=232.2 SFRT=464.4					S=509.0 R=623.5 SFR=1246.9 FT=ns SRT=ns F=509.0 SR=ns T=719.9 SFT=ns FRT=1763.4 SF=ns FR=881.7 ST=ns RT=ns SFRT=2493.8				

Table (4)Effect of some techniques of fertilization with P fertilizer on available Zn (mg/kg soil) in the soil after harvest.

Phosphorus treatments			Techniques of fertilization														
Source (S)	Form (F)	Rate(R) m/kg	BR	Mx	Lc	Md	mean	BR	Mx	Lc	Md	mean	BR	Mx	Lc	Md	mean
			Available Zn (0-10cm)					Available Zn (10-20cm)					Available Zn (20-30cm)				
OSP	P	10	3.27	2.33	2.07	2.40	2.52	1.87	2.33	2.33	2.27	2.20	3.13	2.80	2.33	2.33	2.65
		20	2.87	3.20	2.53	2.40	2.75	2.53	2.67	2.27	2.00	2.378	2.80	3.60	2.60	2.20	2.80
		40	2.73	3.67	2.87	2.80	3.02	2.20	2.27	2.20	2.00	2.17	2.47	6.00	2.60	2.33	3.35
		Mean	2.96	3.07	2.49	2.53	2.76	2.20	2.42	2.27	2.09	2.24	2.80	4.13	2.51	2.29	2.93
	G	10	3.13	3.40	2.60	2.13	2.82	1.80	2.13	1.80	2.07	1.95	3.00	2.47	1.93	1.80	2.30
		20	2.60	3.33	2.87	2.20	2.75	2.80	2.40	1.53	1.93	2.17	2.47	2.27	1.87	1.80	2.10
		40	5.33	3.47	2.40	2.60	3.45	1.93	2.87	2.13	2.27	2.30	1.73	1.93	1.40	1..60	1.67
		Mean	3.69	3.40	2.62	2.31	3.01	2.18	2.47	1.82	2.09	2.14	2.40	2.22	1.73	1.73	2.02
	Mean		3.32	3.23	2.56	2.42	2.88	2.19	2.44	2.04	2.09	2.19	2.60	3.18	2.12	2.01	2.48
TSP	P	10	3.00	2.87	2.47	2.33	2.67	3.27	3.07	2.53	3.07	2.98	1.87	2.00	1.33	1.27	1.62
		20	2.60	2.80	2.53	2.13	2.52	4.07	3.07	3.13	2.07	3.08	1.73	2.20	1.40	1.80	1.78
		40	2.60	2.93	2.20	2.40	2.53	3.33	3.20	2.27	2.20	2.75	2.80	3.87	1.67	1.80	2.53
		Mean	2.73	2.87	2.40	2.29	2.57	3.56	3.11	2.64	2.44	2.94	2.13	2.69	1.47	1.62	1.98
	G	10	2.80	2.53	2.40	2.47	2.55	2.73	2.60	2.07	1.67	2.27	3.73	4.27	2.13	1.73	2.97
		20	2.67	2.40	2.13	2.27	2.37	2.53	2.53	2.00	2.00	2.27	4.67	3.27	2.13	1.67	2.93
		40	2.67	2.93	2.33	2.00	2.48	2.67	2.53	2.00	1.93	2.28	2.80	3.13	2.07	1.80	2.45
		Mean	2.71	2.62	2.29	2.24	2.47	2.64	2.56	2.02	1.87	2.27	3.73	3.56	2.11	1.73	2.78
	Mean		2.72	2.74	2.34	2.27	2.52	3.10	2.83	2.33	2.16	2.61	2.93	3.12	1.79	1.68	2.38
Mean			3.02	2.99	2.45	2.34	2.70	2.64	2.64	2.19	2.12	2.10	2.77	3.15	1.96	1.84	2.43
P		10	3.13	2.60	2.27	2.37	2.59	2.57	2.70	2.43	2.67	2.59	2.50	2.40	1.83	1.80	2.13
		20	2.73	3.00	2.53	2.27	2.63	3.30	2.87	2.70	2.03	2.73	2.27	2.90	2.00	2.00	2.29
		40	2.67	3.30	2.53	2.60	2.78	2.77	2.73	2.23	2.10	2.46	2.63	4.93	2.13	2.07	2.94
Mean			2.84	2.97	2.44	2.41	2.67	2.88	2.77	2.46	2.27	2.59	2.47	3.41	1.99	1.96	2.46
G		10	2.97	2.97	2.50	2.30	2.68	2.27	2.37	1.93	1.87	2.11	3.37	3.37	2.03	1.77	2.63
		20	2.63	2.87	2.50	2.23	2.56	2.67	2.47	1.77	1.97	2.22	3.57	2.77	2.00	1.73	2.52
		40	4.00	3.20	2.37	2.30	2.97	2.30	2.70	2.07	2.10	2.29	2.27	2.53	1.73	1.70	2.06
Mean			3.20	3.01	2.46	2.28	2.74	2.41	2.51	1.92	1.98	2.21	3.07	2.89	1.92	1.73	2.40
OSP		10	3.20	2.87	2.33	2.27	2.67	1.83	2.23	2.07	2.17	2.08	3.07	2.63	2.13	2.07	2.48
		20	2.73	3.27	2.70	2.30	2.75	2.67	2.53	1.90	1.97	2.27	2.63	2.93	2.23	2.00	2.45
		40	4.03	3.57	2.63	2.70	3.23	2.07	2.57	2.17	2.13	2.23	2.10	3.97	2.00	1.97	2.51
TSP		10	2.90	2.70	2.43	2.40	2.61	3.00	2.83	2.30	2.37	2.63	2.80	3.13	1.73	1.50	2.29
		20	2.63	2.60	2.33	2.20	2.44	3.30	2.80	2.57	2.03	2.68	3.20	2.73	1.77	1.73	2.36
		40	2.63	2.93	2.27	2.20	2.51	3.00	2.87	2.13	2.07	2.52	2.80	3.50	1.87	1.80	2.49
Rate		10	3.05	2.78	2.38	2.33	2.64	2.42	2.53	2.18	2.27	2.35	2.93	2.88	1.93	1.78	2.38
		20	2.68	2.93	2.52	2.25	2.60	2.98	2.67	2.23	2.00	2.47	2.92	2.83	2.00	1.87	2.40
		40	3.33	3.25	2.45	2.45	2.87	2.53	2.72	2.15	2.10	2.38	2.45	3.73	1.93	1.88	2.50
Unfertilized (Control)			3.40					3.20					3.33				
LSD 5%			S=0.14 R=0.18 SFR=0.75 SRT=ns FT=ns SRT=ns F=ns SR=0.25 T=0.20 SFT=ns FRT=0.50 SF=ns FR=ns ST=ns RT=ns SFRT=ns					S=0.13 R=ns SFR=ns FT=ns SRT=ns F==0.13 SR=ns T-0.18 SFT=ns SRT=ns SF=0.18 FR=ns ST=0.26 RT=0.31 SFRT=ns					S=0.07 R=0.08 SFR=ns FT-0.14 SRT=0.24 F=ns SR=ns T=0.10 SFT=0.20 FRT=0.24 SF=0.10 FR==0.12 ST=0.14 RT=0.17 SFRT=0.34				

- Technique and rate (TR) :

At the low rate both BR and Mx or Lc and Md showed no significant differences in available Zn , but the Mx technique showed greater available Zn than the Lc technique . At the medium rate the pattern was thus as follows BR > Mx > Lc = Md thus , differences between the Lc and Md techniques were not significant . At the high rate , available Zn of the BR was similar to that of the Mx , neither was the difference between Lc and Md . The former two techniques showed greater availability over the later two techniques.

III-Main effect of technique (T) of 3rd layers .

Data presented in Table 4 of 3rd layers show that available Zn for the unfertilized treatment was 3.33 Mg Zn/kg soil . The Mx technique was superior to all other techniques followed by the BR technique, then by the Lc technique, whereas the Md gave the lowest available Zn .

- Technique and source (TS) :

Data in Table 4 of 3rd layers show an interaction between the technique and the source of P-fertilizer . With both source Mx gave the highest available followed by the BR then by the Lc and Md techniques . The Lc and Md techniques were similar .

- Technique and form (TF) :

The Mx was superior to the BR when the fertilizer was powdered , and reverse occurred when the fertilizer was granulated . The Lc and Md techniques were similar with both forms and gave lower values of available Zn .

- Technique and rate (TR) .

At the low and medium rates both BR and Mx showed no significant differences in contents of available Zn , neither was the difference between Lc and Md . The former two techniques showed greater available over the latter two techniques. At the high rate , Thus treatments arrangement may be as follows . Mx > BR > Lc = Md

- Conclusive assessment on the effect of techniques on available Zn in soil after harvest .

Adding P-fertilizer mixied with seeds after harvest within top , middle , and bottom layers of soil pot gave greater . P-available followed by the localized technique, particularly when used TSP source and granulated form

the broadcast technique gave lower P-available and followed by mixing with soil . High levels of available P or with application of P to the soil reduced the available Zn , possibility of a P-Zn reactions in soil , such as the formation of insoluble Zn_3 $(PO_4)_2$. Megalah (1994) applied P-fertilizer and found a decrease in DTPA – extractable Zn in Soil .

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الملخص العربي

تأثير تقنيات التسميد الفوسفاتي على إمتصاص الزنك في نباتات القمح عند مراحل نمو مختلفة وتيسره في التربة.

وفائي الحسيني أحمد و طه عبدالخالق المغربي
معهد بحوث الأراضي و المياه و البيئة ، مركز البحوث الزراعية -جيزة -مصر

يهدف البحث إلى دراسة تأثير أربع تقنيات للتسميد الفوسفاتي على امتصاص عنصر الزنك بواسطة نبات القمح عند مراحل النمو المختلفة و كذلك تيسره في التربة.

لدراسة أربع طرق تسميد للفوسفور هي (خلط مع البذرة " خ.ب" ونثر على سطح التربه "ن.س" و نثر على سطح التربة مع خلط مع التربه بكاملها " ت" ووضع السماد في حزمة بعمق خمسة سنتيمترات تحت سطح التربة و ثلاث سينتمرات تحت مستوى البذور " ح.ز") ومصدر السماد السوبر فوسفات العادي و السوبر فوسفات الثلاثي و شكل السماد كان أما محبب أو ناعم و المعدلات هي ١٠ و ٢٠ ، ٤٠ ملليجرام مج فو / كجم تربة أي منخفض ومتوسط ومرتفع. أجريت تجربة أصص بثلاث مكررات مستخدماً تصميم كامل العشوائية لتحقيق هدف البحث تم جمع عينات نباتية عند ٤٠ و ٦٠ و ١٢٠ يوم من الزراعة للتحليل الكيمائي و كذلك تم أخذ عينات تربة بعد الحصاد في ثلاث أعماق (صفر -١٠و ١٠-٢٠ و ٢٠-٣٠سم) لتقدير الزنك الميسر. وقد أوضح التحليل الإحصائي للنتائج المتحصل عليها أن هناك تأثير معنوي واضح لتأثير المعاملات المختبرة على امتصاص عنصر الزنك في نبات القمح وتيسره في التربة.

Technical session 3

Soil and Water Resources Management

- *H.A.Shams El-Din, E.H.Omar, M.A.Abd-Alla and M.M. Ragab*
  "Crop productivity, soil salinity and elemental content under low quality water and different soil textures"
  (Soils, Water, and Environment Res Inst., Agric.Res. Center)
- *M.A.Ghazy,M.A.Abou El-soud, E.A.Gazia and E.H.Omar*
  "Effect of some soil amendments on improvement of salt affected soils"
  (Soils, Water, and Environment Res.Inst., Agric.Res. Center)
- *M.M.Ragab, S.M.El-Barbary, M.I.El-shahawy and R.A.Saber*
  "Impact of different water resources and methods of irrigation on productivity of maize and cotton at North Delta"
  (Soils, Water, and Environment Res.Inst., Agric.Res. Center)
- *M.S.M.Abo Soliman, M.I. El-Shahawy, M.A.A.Abd Alla and M.A.Ghazy*
  "Preliminary guideline for yield response to salinity and sodicity of irrigation water under North Delta conditions"
  (Soils, Water, and Environment Res.Inst., Agricultural Res. Center)
- *A.S.El-Hassanein [1], E.A.Eweida [2], G.Abdel Nasser[3] and Karima A.Khallaf*
  "Hydrochemical study of groundwater in El Dakhla oasis"
  1.Dept. of Natural Resources, Inst.of African Res & Studies. Cairo Univ.
  2.Dept. of Geology, Fac.of Sci., Cairo Univ
  3.National Water Research Center)

Crop Productivity, Soil Salinity and Elemental Content Under Low Quality Water and Different Soil Textures

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ABSTRACT

Lysimeters experiments at Sakha Agric. Res. Station were used to evaluate different water sources with drip irrigation system (fresh, drainage, secondary treated sewage and secondary treated sewage blended with drainage water 1:1) under four different soil textures (caly, clay loam, calcareous and sandy) and cultivation of crop rotation, soybean, sugarbeet, sunflower and canola. A split plot design was used where soil textures were the main plots and water sources were the sub-plots. The main results could be summarized as follows:

The highest yields of the four crops were obtained under clay soil. While, the lowest yields were resulted under sandy soil. Using low quality water resulted in significant decrease in crop yields under the four soil types. Using drainage water achieved the highest yield decrements. The salinity of the different soil types was influenced by water salinity. The regression equations revealed that, decrement of yields and salt accumulation in the soils due to irrigation with low quality water take the order: Clay > clay loam > calcareous > sandy. Moreover, sugarbeet was the most salinity tolerant crop. Drainage water was more effective in salt build up under all soil types. Using low quality water enriched the soil with macro and DTPA extractable elements, compared to fresh water and the initial soils. The contents of soybean seeds, sugarbeet roots, sunflower seeds and canola seeds of N, P and K , Zn, Fe , Mn , B, Pb and Co were higher under irrigation with treated sewage water , followed by blended and drainage water compared to fresh water . It could be concluded that low quality water can be safely used in irrigation of salt tolerant and non edible crops under light texture soils and blending secondary treated sewage with drainage water can reduce the salinity hazard of drainage water to achieve higher crop yield.

Key words: Soil textures; Soil salinity; low quality water ;Crop productivity

INTRODUCTION

Use of low quality water in agriculture could be an important consideration when its disposal is being planned in arid and semi-arid regions. The expand of using low quality water in irrigation, drainage; secondary treated sewage or mixing of both sources can save more fresh water for irrigation .The supply of drainage water contains higher levels of salinity and sodicity than the original sources, while treated sewage supply contains higher levels of elements more than fresh and drainage water.

The high salinity of irrigation water can decrease crop yield or even cause failure of crop establishment due to specific ion effect, or total salt build up in the root zone or in adequate maintenance of soil physical properties, Rhoades et al., (1992). For agriculture crop production, various strategies have been advocated for substitution of low quality

water for fresh water. The strategies include mixing of supplied of various qualities, cyclic use of fresh/low quality either irrigation wise or seasonally (Minhas and Gupta, 1993).

Oster, (1994) suggested three changes form the stander irrigation practices for the use of low quality water. improvement in water management, maintenance of soil physical properties to assure soil tilth and adequate soil permeability. Feizi and Rezeal, (1997) reported that irrigation of clay loam soil by drainage water achieved the lowest yields of sunflower, cotton and barely followed by drainage mixed with fresh water.

EL-Mowelhi et al. (1999), revealed that the maximum cotton seed yield was achieved from clay and silty soils irrigated by 100% of soil available water , compared to calcareous and sandy soils.

Omar et al (2001) showed that irrigation with drainage or blended sewage water increased the elemental content of sugar beet and canola plants. Selem et al (2000) revealed that irrigation with sewage water for a long period leads to an increase in Cu, Zn and Mn content in the different plants of sour orange and orange growth in Abou Rawash sandy soil. EL-Sokkary and Sharaf (1996) clear that bioaccumulalion ratios of Zn in plants followed the sequence: chard > spinach > lettuce > roquette > coriander > clover, where these plant species grown in alluvial soil and irrigated with waste water. Eid and Shreif (1996) showed that the P,N, Mn and Ni contents of barley, broad bean and rape seed were increased significantly with mixed water compared to fresh water. These increases amount are 18% and 9% for Mn and Ni, respectively in mixed waste water treatment (1:2) compared to fresh water. Fatma El-Shafei and El-Koumey (1994) revealed that application of sewage effluent to the clay soil increased the uptake of N, P, K, Na, Cu, Co, and Pb by fenugreek, barley and mallow plants. Koriem (1994) showed that drainage water significantly increased the concentrations of Fe, Cu, Ni and Cd in fruits of egg plant grown in clay soil and N and Cu in fruits of egg plant grown in sandy loam soil in comparison with fresh water.

Omar et al (2001) observed that soil salinity and alkalinity were increased due to irrigation with blended waste water or drainage water. They also showed that soil available N, P and K and DTPA extractable elements were increased as a result of using blended waste water or drainage water. Selem et al (2000) reported that continuous irrigation with sewage water led to increase of soil ECe ,soil available Fe ,Zn ,Cu, Mn and heavy metals (Pb and Co) comparing to the virgin soil.

EL-Sokkary and Sharaf (1996) clear that irrigation of alluvial or lacustrine soils with wastewater resulted in enrichment by Cd and to some extent by Zn. Fatma El-Shafie and El-Koumey (1994) showed that using sewage effluent in irrigation of clay soil increase soil ECe, total N,

available P and DTPA extractable Cu, Co and Pb. Koreim (1994) observed that drainage water (C4S1) caused a significant increase in ECe, SAR, soil available, P,K and DTPA extractable Zn in sandy loam soil . Abd EL-Aal et al (1991) found that the soil contents of total and available forms Pb, Ni , Cd ,Co and Cr within the surface layer (60cm) are increased by the period of irrigation with sewage water.

The objectives of the present work are to assess the effect of different irrigation water sources on some field crops yield and their elemental contents as well as soil salinity and availability of elements under different soil textures.

MATERIALS AND METHODS

Lysimeter (2m length x 1m width x 1.8 m depth) experiments were used in this study at Sakha Agric. Res. station. The experimental setup was designed to evaluate different water sources with drip irrigation system (fresh, drainage, secondary treated sewage and secondary treated sewage blended with drainage water 1:1) under four different soil textures (Clay, Clay loam, Calcareous and Sandy). Table (1) show some physical and chemical properties of the different water sources.

Table (1) Chemical and biological properties of the different water sources.

Water sources	EC, dS/m	SAR	COD, mg/l	BOD, mg/l	NH4 (N),mg/l	NO3 (N), mg/l	Suspended solids ,mg/l	Dissolved solids , mg/l	
Fresh	0.53	1.45	23	9	1.3	5 5	240	530	
Drainage(D)	1.55	3.95	45	23	12	29	410	1540	
Sewage(S)	1.25	4.65	127	75	17	38	920	1250	
S+D(1:1)	1.41	4.36	87	48	14	33	665	1390	
	Elements (ppm)								
	N	P	K	Zn	Fe	Mn	B	Pb	Co
Fresh	2.42	0.315	3.4	0	0.025	0.055	0.06	0.032	0 02
Drainage(D)	16.32	0.418	8.3	0.01	0.213	0.028	0.01	0.084	0.004
Sewage(S)	23.86	4.85	6.5	0.09	0.331	0.945	0.21	0.041	0.016
S+D(1:1)	20.11	2.72	7.4	0.06	0.275	0.485	0.12	0.061	0.01

Table (2)Some physical and chemical properties of the soils used :

Soil type	Soil depth cm	Coarse sand %	Fine sand %	Silt %	Clay %	Texture grade	Bulk density (g/cm3)	Field capacity (%by weight)	Permanent wilting point(%by weight
Clay	0-30	8.3	9.85	29.65	52.2	Clayey	1.13	44.3	23.7
	30-60	8.8	17.78	26.26	47.14	Clayey	1.17	43.6	22.6
	60-90	7.16	21.4	22.7	48.74	Clayey	1.21	39.6	20.4
Loam	0-30	10.56	18.52	35.62	35.3	Clay loam	1.15	40.2	20.5
	30-60	9.02	24.48	32.34	34.16	Clay loam	1.18	36.3	17.4
	60-90	7.6	23.15	34.3	34.94	Clay loam	1.25	33.7	16.6
Calcareous	0-30	10.38	28.66	25.68	30.28	Clay loam	1.36	15.2	8.2
	30-60	16.76	30.75	24.35	28.14	Sandy clay loam	1.44	13.6	7.7
	60-90	27	32.46	19.48	21.06	Sandy clay loam	1.33	16.8	10.3
Sandy	0-30	70.56	20.66	4.54	4.15	Sandy	1.77	10.6	3.4
	30-60	67.27	26.87	2.14	3.72	Sandy.	1.75	9.5	3.3
	60-90	60.2	29.6	3.14	6.58	Sandy.	1.63	8.3	2.9

A split plot design was used where the main plots were devoted to soil texture. The sub plots were assigned to the different irrigation water sources. Soybean (Giza 21 v.) was sown in summer 1999 followed by sugar beet (Raspoly v.) in winter 1999/2000 . Sunflower (Vidoic v.) in summer 2000 and canola (Pactol v.) in winter 2000/2001. All the recommended agronomic practices were done. Plant samples were dried, miled and wet digested according to Page (1982). Soil available Zn, Fe, Mn, B, Pb and Co were extracted by DTPA solution (Lindsay and Norvell, 1978). Soil available N was extracted by K2SO4 solution 0.5 N and determined using Automatic Micro-Kjeldahl. Soil available P was extracted by Na HCO3 0.5 N and determined according to Murphy and Riley, (1962). Soil available K was extracted by ammonium acetate 1 N and determined using the flame- photometer according to Page (1982). The heavy metals were determined by the Atomic Absorption Spectrophotometer. The data was analyzed according to Chocran and Cox (1960).

Data of yield decrement (of soybean, sugarbeet sunflower and canola) under different soil types and different soil salinity virsus irrigation water salinity was evaluated through linear equations. The yield decrement or soil salinity represent dependent variable while irrigation water salinity expressed as EC dS/m represent independent variable and the equation takes the following formula: Y= ax + b where Y= yield decrement (%) or soil salinity, x= irrigation water salinity EC dS/m, b= intercept and a= slope.

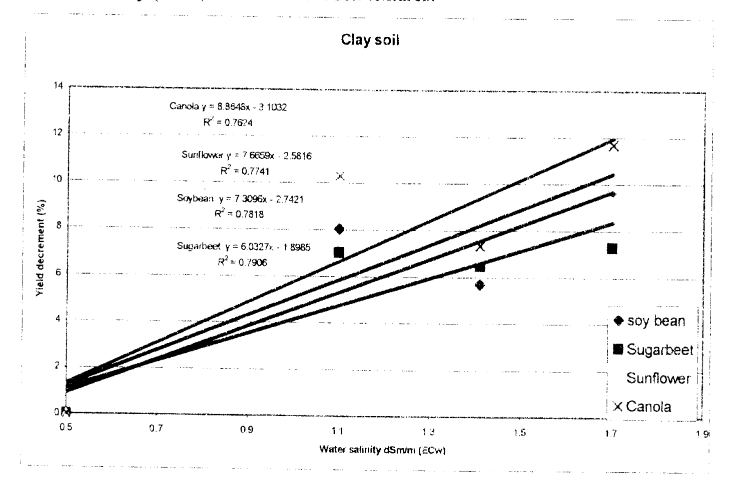
RESULTS AND DISCUSSION

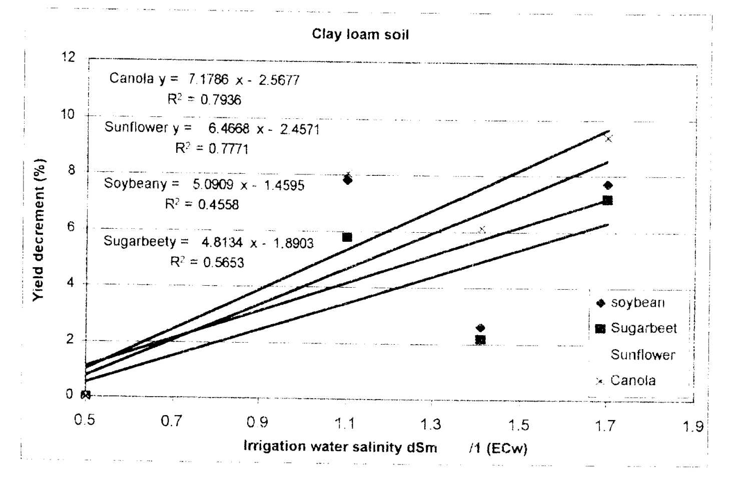
Yield of different crops:

Data in Table (3) showed that the soil types highly significant affect the yields of soybean, sugarbeet, sunflower and canola crops. The highest yields of the four crops were obtained under clay soil conditions. While the lowest yields were resulted under sandy soil. This could be attributed to the higher fertility of the clay soil and vice versa for sandy and calcareous soils. Irrigation by water sources had highly significant effect on sugarbeet yield and significant effect on yield of soybean, sunflower and canola. Using low quality water in irrigation resulted in significant decrease in yield of all crops under the four soil types. Irrigation with drainage water achieved the highest yield decrements (Table 3) of the four crops. While treated sewage water resulted in the lowest yield decrement of the four crops under the four soil types. It is obvious from data that the yield decrement due to low quality water, drainage or secondary treated sewage was higher in the clay soil than in the other soil types. This may be due to low water permeability of the clay soil and the accumulation of salts, which inhibited plant growth and yield. Sugarbeet crop was less affected by the low quality water where the root yield decrement ranged between 1.51 to 7.3% in the four soil types. On the other hand canola crop was more affected by the low quality of irrigation water followed by sunflower. The highest decrements of canola seed yield 11.7, 9.35, 9.07 and 8.94 % under clay, loamy, calcareous and sandy soil condition irrigated with drainage water, respectively. These results were similar to those obtained by, El-Mowelhi et al. (1999); Rhoades et al. (1992) and Minhas and Gupta (1993).

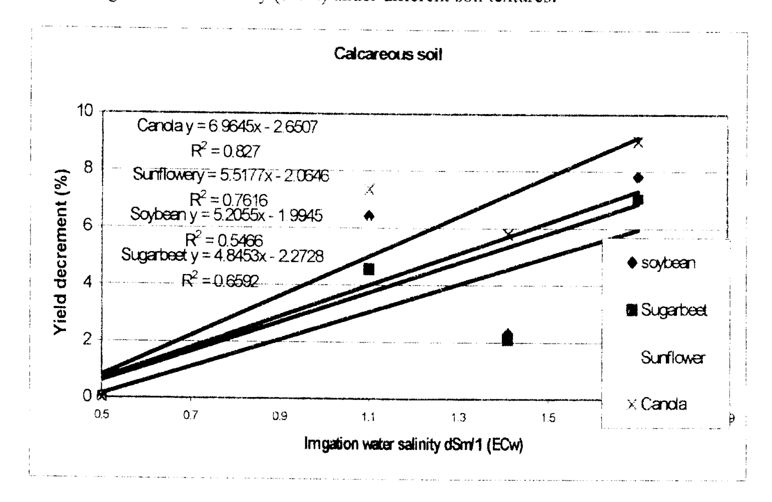
Different linear equations for each crop and representative graphics describe the equations are presented in Fig (1). From the regression equations it could be arrange the crops according to its tolerance to salinity of irrigation water as follows :sugarbeet > soybean > sunflower >canola .

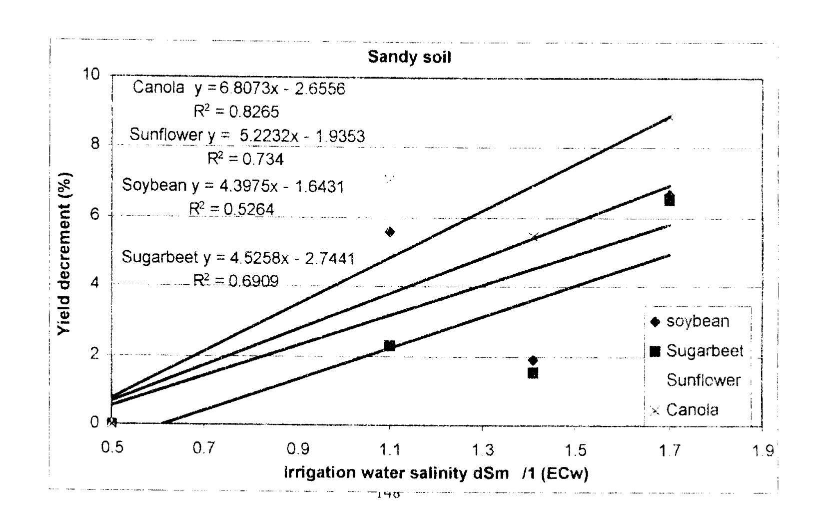
Fig (1): Yield decrements of different crops as affected by irrigation water salinity (dS/m) under different soil textures.





Cont. Fig (1): Yield decrements of different crops as affected by irrigation water salinity (dS/m) under different soil textures.





Soil salinity:

Fig (2) show the effect of irrigation water sources on soil salinity under different soil types. It is obvious from the results that increasing the salinity of irrigation water increased the salinity of the different soil types. The long term use of low quality water was more pronounced in increasing the salinity of different soil types, whereas the lowest soil salinity was obtained after harvesting of the first crop (soybean) while the highest level was achieved after harvesting of the last crop (Canola) under different soil types. These results are in agreement with those obtained by Rhoades et al. 1992; Koriem , 1994 ; Feizi and Rezeai ,1997 ; Selem et al. 2000 and Omar etal. 2001. The regression equations in Fig 2 revealed that the accumulation of salts in the soils due to irrigation with low quality water take the following order: Clay> clay loam > calcareous > sandy. Drainage water was more effective in salt build up under all soil types.

Soil elemental content:

Table (4) illustrated the values of the soil available elements in the different soil types after harvesting canola crop at the end of the experiment. The obtained results revealed that using low quality water in irrigation of the four crops enriched the soil with macro and DTPA extractable elements, compared to fresh water and the initial soils.

Data also clear that soil available elements decreased to some extent under irrigation with fresh water. Using drainage water in irrigation increased soil available K, and Pb, while all elements were increased under secondary treated sewage irrigation compared to the other water sources. It is obvious from the results that the element contents of the different soil types take the following order: Clay> loam> calcareous > sandy. The obtained results are in agreement with those obtained by Omar et al. 2001; Selem et al., 2000 and Koreim , 1994.

Table (3): Different crop yields and yield decrements as affected by irrigation water salinity under different soil textures.

Soil type	Water sources	Water salinity ECw (dS/m)	Soil salinity dS/m	Yield kg/fed	Yield decrement (%)	Soil salinity dS/m	Yield kg/fed	Yield decrement (%)
			Soybean			Sugarbeet		
Clay	F	0.5	3.71	538.9	0	3.82	27770	0
	D	1.7	4.37	486.4	9.74	4.56	26203	7 3
	S	1.1	4 19	508.2	5.69	4.45	27266	6.49
	S:D 1:1	1.41	4.33	495.6	8.03	4.52	27224	7.03
Loam	F	0.5	1.89	496.0	0	2.11	25838	0
	D	1.7	2.69	457.8	7.71	2.76	25418	7.19
	S	1.1	2.59	483.0	2.62	2.64	25712	2.16
	S:D 1:1	1.41	2.66	457.4	7.81	2.68	25502	5.76
Calcareous	F	0.5	1.75	360.4	0	1.8	14620	0
	D	1.7	2.06	332.2	7.82	2.12	14292.4	7.09
	S	1.1	1.99	352.1	2.3	2.02	14523.4	2.09
	S:D 1:1	1.41	2.04	337.3	6.42	2.13	14410	4.55
Sandy	F	0.5	1.15	318.5	0	1.19	14179	0
	D	1.7	1.36	297.4	6.65	1.39	11906	6.53
	S	1.1	1.31	312.5	1.9	1.33	9116	1.51
	S:D 1:1	1.41	1.34	300.7	5.59	1.4	8182.82	2.3
Soil type			Sunflower			Canola		
Clay	F	0.5	4.25	1684	0	4.51	1546	0
	D	1.7	5.03	1418	9.89	5.33	1365	11.7
	S	1.1	4.62	1499	6.89	5.13	1432	7.34
	S:D 1:1	1.41	4.92	1442	9	5.16	1386	10.3
Loam	F	0.5	2.28	1197	0	2.35	1302	0
	D	1.7	2.96	956	8.67	3.28	1180	9.35
	S	1.1	2.73	1037	4.9	2.85	1222	6.13
	S:D 1:1	1.41	2.77	1091	7.06	2.82	1197	8.06
Calcareous	F	0.5	2.01	1176	0	2.13	1113	0
	D	1.7	2.37	1030	7.43	2.52	989	9.07
	S	1.1	2.28	1067	4.15	2.42	1025	5.79
	S:D 1:1	1.41	2.31	1045	6.15	2.45	1008	7.34
Sandy	F	0.5	1.32	1092	0	1.4	1155	0
	D	1.7	1.56	1014	7.12	1.65	1010	8.94
	S	1.1	1.48	1051	3.78	1.57	1048	5.45
	S:D 1:1	1.41	1.51	1027	5.96	1.6	1031	7.05

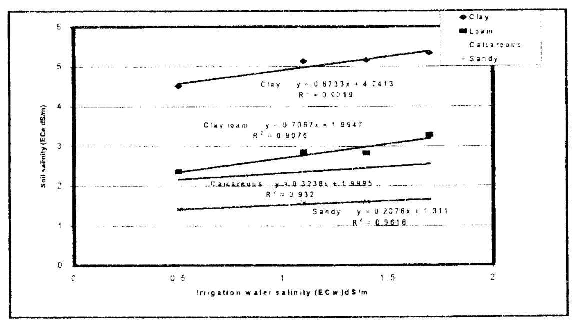


Fig (2): Salinity (ECe dS/m) of different soil texture as affected by irrigation water salinity (ECw)

Table (4) Soil available elemental content (ppm) after four crops.

Soil texture	Water sources	N	P	K	Zn	Fe	Mn	B	Pb	Co
Clay	Initial	23	17.4	360	2.96	18.4	24.8	3.77	3.24	1.38
	F	25	17.1	352	3.11	18.1	24.5	3.73	3.17	1.35
	D	28	18.2	429	4.25	22.5	25.1	3.63	3.91	2.11
	S	35	18.5	367	4.87	23.4	28.9	5.81	3.42	2.32
	S:D (1:1)	32	18.3	406	4.31	20.4	22.4	3.62	3.63	2.21
Loamy	Initial	19	15.7	315	2.73	15.5	17.1	3.45	1.37	1.23
	F	19	15.6	297	2.66	15.3	16.9	3.37	1.31	1.21
	D	20	16.4	392	3.17	18.3	21.2	3.54	2.94	1.05
	S	22	17.5	375	3.23	20.2	24	4.87	2.73	1.19
	S:D (1:1)	21	17.2	372	3.11	17.5	23.9	4.39	1.87	1.68
Calcareous	Initial	14	14.8	252	2.55	11.7	1.9	1.64	1.26	0.75
	F	15	14.6	247	2.52	11.7	1.9	1.61	1.21	0.71
	D	17	15.1	283	2.65	12.9	2.1	1.76	2.35	0.85
	S	20	16.8	243	2.84	14.1	3.6	2.14	2.23	0.81
	S:D (1:1)	18	15.7	263	2.71	13.4	2.6	1.93	2.26	0.84
Sandy	Initial	7.5	3.61	117	1.49	3.77	2.52	1.35	1.06	0.38
	F	7.4	3.57	113	1.47	3.73	2.47	1.32	0.98	0.37
	D	7.8	6.13	154	1.54	3.75	2.91	1.51	2.06	0.48
	S	8.5	5.39	139	1.78	5.39	3.1	1.73	1.14	1.09
	S:D (1.1)	9.5	5.89	145	1.68	4.97	4.5	1.65	1.66	0.67

Plant elemental contents:

The obtained results illustrated in Table (5) clear that the contents of soybean seeds, sugarbeet roots, sunflower seeds and canola seeds of N, P and K, Zn, Fe, Mn, B, Pb and Co were higher under irrigation with treated sewage water, followed by blended and drainage with treated sewage water compared to fresh water.

In general, soybean seeds content of N, K, P, Zn, Fe, Mn, B, Pb and Co contents were higher under clay soil than the other soil types. Sugarbeet roots content of N and P were higher in loamy soil than in other soil types, while the roots content of the other elements were higher in the clay soils. Clay soil was more effective in supplying sunflower with N, P, K Fe, Pb and Co, while loamy soil was more effective in supplying Zn, Mn and B. Canola seed content of N, P, K, Zn and Fe were higher in clay soil, while Mn content was higher under calcareous soil condition irrigated with treated sewage water.

It is clear from results that elements content of the different crops were lower under sandy soil condition irrigated with fresh water, compared to the other soil types. These results agree with the results obtained by El-Keiy, (1983) and Omar et al. (200).

Table (5) Elemental content of soybean seeds ,sugaarbeet roots , sunflower seeds and canola seeds as affected by different water sources under different soil textures

Water Sources	Elementsppm	soybean				sugarbeet				sunflower				canola			
		clay	loam	Calcar-ous	sandy	clay	loam	calcareous	sandy	clay	loam	calcareous	sandy	clay	loam	calcareous	sandy
F	N(%)	2.88	2.86	2.8	2.71	1.9	2	1.7	1.65	2.52	2.3	2.03	2.01	2.48	2.41	2.02	2.07
D		2.91	2.85	3.17	2.75	1.8	2.05	1.65	1.6	2.51	2.4	2.17	1.99	1.97	2.3	2.07	1.78
S		2.96	2.95	3.15	3.15	2.2	2.15	1.75	1.8	2.73	2.6	2.9	2.3	2.63	2.29	1.97	2.11
S.D (1 : 1)		2.8	2.92	3.1	3.03	2.1	2.1	1.72	1.7	2.61	2.5	1.99	2.1	2.6	2.28	1.62	1.81
F	P(%)	0.37	0.21	0.32	0.25	0.2	0.15	0.12	0.12	0.19	0.15	0.18	0.15	0.19	0.17	0.14	0.15
D		0.5	0.25	0.51	0.34	0.2	0.17	0.14	0.13	0.21	0.17	0.21	0.16	0.23	0.21	0.18	0.17
S		0.57	0.31	0.55	0.37	0.2	0.21	0.15	0.14	0.26	0.24	0.26	0.22	0.25	0.24	0.2	0.21
S.D (1 : 1)		0.49	0.27	0.48	0.36	0.2	0.19	0.14	0.13	0.22	0.18	0.23	0.17	0.22	0.22	0.19	0.19
F	K(%)	0.95	0.91	0.68	0.68	1.1	1	0.9	0.8	1.5	1.3	1.5	1.3	1.4	1.5	1.4	1.3
D		0.96	0.92	0.76	0.76	1.2	1.1	1	0.9	1.9	1.5	1.7	1.4	1.5	1.6	1.6	1.6
S		1.01	0.96	0.85	0.78	1.5	1.4	1.3	1.2	2.1	1.9	1.9	1.9	1.9	1.9	2.2	2.1
S.D (1 : 1)		0.98	1.01	0.81	1.01	1.3	1.3	1.1	1	1.8	1.6	1.6	1.6	2	2	1.7	1.7
F	Zn ppm	22.5	18.4	53	25.5	28	26	24	22	37	41.2	25.5	33.2	40	35	27.5	22.5
D		28	21	50	28.6	30	29	26	25	32.5	44.1	26.2	35.2	32.5	32.5	27.5	30
S		30	28	61	32.5	35	33	29	28	44.2	46.2	31.2	37.5	45	35	25	27.5
S.D (1 : 1)		26.5	26.1	54	30	32	31	27	26	37.3	45	27.1	34.1	42	37.5	25	30
F	Fe ppm	465	365	410	375	750	735	680	640	820	715	560	551	1502	860	1983	1050
D		520	528	508	447	920	900	830	820	840	815	620	615	933	1008	1070	1233
S		537	542	523	521	###	1020	950	910	1115	940	680	660	820	1053	987.5	1085
S.D (1 : 1)		529	459	512	468	###	1000	850	860	940	850	590	620	878	1350	1123	1178
F	Mn ppm	19.5	16.2	29.5	20	40	41	36	34	44.1	44.1	44.1	36.9	40	42.5	50	40
D		30	23.5	32	25	35	36	38	36	46.2	50.1	48	37.2	37.5	42.5	45	22.5
S		32.5	33	33.6	30.5	48	46	39	38	51.2	55.3	55.1	44.1	47.5	45	37.5	35
S.D (1 : 1)		31	25.5	30.7	30.2	42	41	37	36	46.2	48.1	47.2	38.6	42.5	42.5	37.5	40
F	B ppm	35	31.5	30.5	33	1.3	1.2	1.05	1	1.51	1.7	1.4	1.3	1.45	1.6	1.4	1.3
D		46.5	38	39.5	35.5	1.7	1.6	1.4	1.3	1.8	2.2	1.8	1.5	1.8	2.2	2	1.9
S		52	45	48	37.2	2.1	2	1.7	1.6	2.42	2.9	2.3	1.7	2.5	2.8	2.6	2.5
S.D (1 : 1)		47	35.5	44.5	37	1.9	1.8	1.5	1.3	2.11	2.3	2.1	1.6	2.1	2.15	2.1	2
F	Pb ppm	3.5	2.3	2.5	2.6	14	13	11	10	16.1	12.5	14.5	15	15.7	13.5	15.5	16
D		6	4.3	3.3	4.8	22	21	19	18	17.2	18.7	19.2	25.1	29	27	29	30
S		5.5	5.1	3.8	5.1	25	24	21	20	22.3	22.5	22.1	33.2	34.2	31	33	35.5
S.D (1 : 1)		4.9	3.8	3.7	4.2	23	22	20	19	18.1	19.2	18.1	27.1	28.1	26	28	31
F	Co ppm	2.8	2.4	2.3	2.1	1.5	1	0.8	0.7	1.6	1.3	1.31	1.6	1.5	1.35	1.45	1.7
D		3.7	3.5	3.5	2.9	1.2	1.1	1	0.9	2.1	1.4	1.62	1.9	2.3	1.7	1.8	2.2
S		3.9	3.7	3.7	3.6	1.4	1.3	1.2	1.2	3.2	2.7	3.1	3.3	3.1	2.95	3.05	4.5
S.D (1 : 1)		3.7	3.6	3.4	3.2	1.2	1.1	1	1	2.7	2	2.42	2.5	2.8	2.15	2.25	3.15

CONCLUSION

It could be concluded that low quality water can be safely used in irrigation of salt tolerant crops and non edible crops under light texture soils and blending treated sewage with drainage water can reduce the salinity hazard of drainage water to achieve higher crop yield.

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الملخص العربي

إنتاجية المحاصيل مع ملوحة التربة والمحتوى العنصري عند الري بمياه منخفضة الجودة أراضى مختلفة القوام

حسن على شمس الدين- السعيد حماد عمر- محمد عبد الله احمد -محمد مصطفى رجب

أقيمت تجارب ليزيمترات في محطة البحوث الزراعية بسخا وذلك لتقييم الري بمصادر مياه مختلفة (عذب، صرف صحي معالج ، صرف زراعي ، صرف صحي معالج + صرف زراعي بنسبة ١:١) و الري بالتنقيط تحت ظروف أراضى مختلفة القوام (طينية- طينية سلتيه- جيرية- رملية) وكذلك زراعة ٤ محاصيل مختلفة (فول صويا- بنجر سكر - عباد شمس - كانولا) . وتم استخدام التصميم الإحصائي في القطع المنشقة حيث كانت المعاملات الرئيسية هي أنواع الأراضي والمعاملات الشقية هي مصادر مياه الري وتتلخص أهم النتائج فيما يلي:

كانت أعلي قيم المحصول عند الزراعة في الأرض الطينية بينما كانت اقل القيم في حالة الأرض الرملية وذلك للمحاصيل الأربعة المستخدمة. أدى استخدام المياه المنخفضة الجودة إلي خفض الناتج المحصولي تحت ظروف الأراضي المختلفة المستخدمة وعند استخدام مياه الصرف الزراعي في الري إلى أقصى انخفاض في إنتاجية المحاصيل أعلى قيم لملوحة التربة وبينت نتائج معادلات الانحدار أن تجمع الأملاح في الأراضي اخذ الترتيب: طينية> طينية سلتيه > جيرية > رملية . كان اقل المحاصيل تأثرا بتجمع ملوحة التربة هو محصول بنجر السكر تحت ظروف الأراضي المختلفة.

أدى استخدام المياه العادمة في الري إلي زيادة مستوى العناصر في التربة والنبات وكانت أعلى القيم عند استخدام مياه الصرف الصحي المعالج .

ويمكن استنتاج انه يمكن استخدام المياه العادمة بأمان في ري الأراضي خفيفة القوام وزراعة المحاصيل التي لا تؤكل طازجة والمتحملة للملوحة وأيضا يؤدى خلط مياه الصرف الزراعي مع مياه الصرف الصحي المعالج إلى تخفيف الضرر الناتج من ملوحة مياه الصرف الزراعي.

Effect of Some Soil Amendments on Improvement of Salt Affected Soils.

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ABSTRACT

A pilot experiment was conducted at El-Hamoul, Kafr El-Shiekh Governorate during three successive seasons 1999/2000, 2000 and 2000/2001 to study and evaluate the role of sulphur (1.4 ton/fad.) with organic manure and treated sewage sludge in two rates (15.0 and 22.5 ton / fad.) on the improvement and productivity of salt affected soil at North Delta. Also, to study their effects on yield of three successive crops i.e. sugar beet, seed melon and Egyptian clover.

The obtained results could be summarized as follows:

- Soil salinity was slightly decreased with sulphur application and effect of sulphur was more pronounced with organic manures. Also, soil salinity was decreased by the time.

- Soil pH and ESP values were decreased due to application of sulphur and to reduction in these values was more pronounced when sulphur was mixed with the organic manure, especially treated sewage sludge. Soil pH was affected by the rate of organic manures and the time.

- Soil organic matter content was decreased with sulphur, but it was increased when the sulphur was mixed with the organic manures.

- Sulphate content in soil was increased with sulphur application and the increment was more pronounced when the sulphur was mixed with organic manure.

- Application of sulphur mixed with organic manure increased NPK of soil especially with higher rate of treated sewage sludge.

- The addition of sulphur significantly increased the root and the sugar yield of sugarbeet, especially with treated sewage sludge.

- The residual effect of sulphur and organic manures increased the yield of seed melon in the second season and clover in the third season especially when sulphur was combined with sewage sludge.

INTRODUCTION

Serious soil problems, such as salinity and alkalinity occur in many arid and semi-arid regions which inhibit plant growth. Most of these soils are normally alkaline in reaction, therefore many crops exhibit symptoms of nutritional deficiencies. This is often attributed to the

failure of the plant to assimilate some of the nutrient elements such as phosphorus, iron, copper, manganese and zinc. The deficiency is not a results of absolute deficiency of the elements but due to low of their solubility (*Stromberg and Tisdal 1979 and Shata et al 1990*).

Attention has been paid to the application of elemental sulphar as a soil amendment to correct soil alkalinity. Elemental must be oxidized in the soil to be chemically effective. The rate of sulphur oxidation depends on several factors such as soil moisture content (*Janzen and Bettany 1987*) and particle size of sulphur (*Lee et al, 1988*).Also, the microbial population, temperature, organic matter and redox potential can effect in the biological oxidation of elemental sulphar. (*Gupta et al, 1988; Lawrence et al , 1988; and Dawood et al, 1990).* Elemental sulphur is oxidized by soil microorganisms to sulphuric acid which in turn lowers soil pH, and increase the availability of certain plant macro-and micro-nutrients, notably phosphorus, iron, manganese and zinc (*Moustafa et al, 1990*). In addition, sulphur is considered as an essential nutrient because it is required in smaller amount than the macro elements but in higher quantities than the micro-nutrients. The function of sulphur in plant lies in its participation in protein structure in the form of sulphur bearing amino acids, cystine, cysteine and methionine *(Nicholas 1963*).

Under alkali soil, the addition of organic materials is helpful especially where sulphur is added to correct soil alkalinity. They enhance the microbial activity that promote the oxidation of sulphur to sulphate form (*Tomhan et al, 1970* and *El-Magraby et al, 1996*). On the other hand, many investigators suggested that sulphur and organic manures can be successfully used for controlling soil salinity and alkalinity and increasing soil productivity (*Beaton and Wagner, 1985, Ghazy (1994)* and *Abd Allah, M. 1998*).

Sugarbeet could be extensively grown under the Egyptian conditions because of its adaptation to a wide range of climate, and its tolerance to salinity. In sugarbeet , sulphur deficiency may result not only in decreasing sugar yield but may also affected sugar beet quality (*Sexton, 1996*)

The purpose of this investigation is to study and evaluate the role of sulphur with organic manure on the improvement and productivity of salt affected soils at North Delta.

MATERIALS AND METHODS

Pilot experiments were conducted at Abo-Skien sector near El-Hamoul, Kafr El-Shiekh Governorate during three successive seasons 1999/2000, 2000 and 2000/2001 to evaluate the role of sulphar with organic manure on the improve of some chemical properties as well as productivity of salt affected soil.

An experimental field was selected to represent a typical heavy clayey soil with water table depth 85 cm. Soil samples were taken before planting and after harvesting. The main soil characteristics of soil under study as well as the level of some nutrients were determined according to (*page, (1982)* and *Klute, (1986)* and listed in Table (1).

Organic materials {Treated Sewage Sludge (TSS) and farmyard Manure (FYM)} were used. Sewage sludge was air-dried about three months in summer season. Some chemical properties of these organic manures are given in Table (2).

Sulphur dose (1.4 ton/fad.) was calculated according to *El-Gabaly, (1972)*, which equivalent to gypsum requirements (7 ton/fed.). The gypsum requirements was calculated to reduce the ESP to 12 %, according to the *U.S. Salinity Laboratory, (1954)*.

A Complete randomized block design with four replicates was used and plot area was 42 m^2. The experimental area included six treatments representing sulphur requirement and two levels of organic manures as follow:

1- Control (without treatment)
2- 1.4 ton sulphur (S).
3- 1.4 ton sulphur (S) + 15 ton treated sewage sludge /fad.(TSS)I
4- 1.4 ton sulphur (S) + 22.5 ton treated sewage sludge /fad. (TSS)II
5- 1.4 ton sulphur (S) + 15 ton farm yard manure /fad. (FYM)I
6- 1.4 ton sulphur (S) + 22.5 ton farm yard manure /fad.(FYM)II.

The mixture of sulphur with organic manure was added in one dose to the surface before the first crop and the experimental field was prepared for cultivation. Sugarbeet (Raspoly V.) was planted in Oct. 12th 1999 and harvested in Apr. 21st 2000. Seed melon was planted after sugarbeet in the same site in June 15th 2000 and harvested in Sept 25th 2000 followed by Egyptian clover in winter growing season 2000/2001. The fertilizer levels of N, P and k were added for each crops according to the recommended dose of North Delta. The irrigation water was applied to

refill the root zone to field capacity plus 10% as leaching requirements. At harvesting time , 10.5 m2 area from each plot were taken to determine the yield and some components for the three crops. Sucrose were determined according to Mc Ginnus, (1971).

Data were statistically analyzed according to Snedcor and Cochran, (1974).

Table (1) : Some chemical and physical characteristics of experimental area.

Soil Properties		Values	
		0-30 cm	30-60cm
pH (1: 2.5 soil water suspension		8.21	8.22
Ece (soil paste extract) at 25°C dSm^{-1}		5.01	20.70
Soluble Cations and anions(soil past extr.) $megl^{-1}$			
Ca^{2+}		7.36	14.72
Mg^{2+}		8.66	17.32
Na^{+}		38.40	180.00
K^{+}		1.40	3.00
Co^{2-}		-	-
HCO_3		4.51	2.54
Cl^{-}		35.29	194.00
So_4^{2-}		16.02	18.50
Exchangeable Sodium Percentage (ESP)	%	26.75	32.64
Cation Exchange Capacity (CEC) meq/100g Soil		44.33	42.52
Total carbonate	%	2.06	1.37
Organic matter	%	1.29	0.54
Total nitrogen	%	0.092	0.087
Available – P (extracted by NaHCO3)	ppm	11.99	9.66
Available-K(extracted by ammonium acetate)	ppm	410.0	428.1
Particle size distribution			
Sand %		4.79	7.20
Silt %		31.71	26.40
Clay %		63.50	66.40
Texture class		Clayey	Clayey
Field capacity,	%	46.55	45.20
Welting Point,	%	25.30	24.10
Available soil moisture,	%	21.25	21.10
Bulk density,	gm/cm^3	1.32	1.45

Table (2): Some chemical characteristics of the used organic manure

Sources of organic manure	VARIABLE														
	pH (1:2.5 org manure – water)	EC (1:10 org. manure – water at 25 ° C	Soluble ions (1:10 water extr.) meq /L								O.M %	C/N ratio	Total N %	Total P %	Total K %
			Na^{+}	K^{+}	Ca^{++}	Mg^{++}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}					
Sewage Sludge	6.25	2.52	11.65	0.65	8.6	5.0	-	6.41	12.50	6.99	39.90	14.59	1.91	0.88	1.76
Farmyard Manure	7.30	3.81	19.73	11.09	4.22	1.85	-	4.75	18.81	13.33	22.86	13.01	0.80	0.50	1.54

RESULTS AND DISCUSSION

I-Effect of soil amendments on some chemical properties:

1- Soil Salinity (EC dS/m):

Results in Table (3) indicated that the addition of sulphur amendment, decreased soil salinity as reflected on the EC of soil. The values of EC was slightly decreased from 5.48 to 4.83 dS/m and from 20.11 to 12.03 dS/m in surface and subsurface layers, respectively.

The aforementioned effect of sulphur was more pronounced when it combined with organic manure as shown in Table (3). The rate of decrement below the control reached 22.80 and 30.66% when sulphur mixed with 15 and 22.5 ton sewage sludge / fed, respectively in the upper soil depth (0-30 cm) while it reached 13.14 and 19.71 % in the same soil depth of sulphur mixed with 15 and 22.5 ton farmyard manure, respectively.

The effectiveness of different treatments on soil salinity can be arranged in the following order: (S + TSS) >(S + FYM) >(S) > Control

The EC values of soil were declined with the time, maybe due to enhance leaching of salts. Created Na^+: Ca^{2+} and Cl^-: SO_4^{2-} balances seem to increase water permeability and leaching of salts. Depending on the rate of sulphur oxidation and leaching processes, soil salinity fluctuates but ends up with values below the salinity of control. The same conclusions were achieved by Hilal, (1990), El-Maghraby et al, (1996) and Abd-Allah, (1998). On the other hand, the favorable effects of organic manure on reducing EC values could be attributed to the increase in soil aggregation, hence, favorable structure which leads to adequate soil aeration and permit a good drainage of the excessive soluble salts. The same results were obtained by Ghazy,(1994), Talha, (1997) and Abd Allah,(1998).

2- Exchangeable Sodium Percentage (ESP):

Data in Table (3) show that the ESP values were decreased in the plots, which treated with sulphur alone compared with untreated soil. ESP values were decreased from 26.75 and 32.78 in the control to 18.47 and 21.59 in surface and subsurface layer . , respectively with addition of sulphur The gradual decrease in ESP values extended in the studied soil after the second and third seasons. The effectiveness of sulphur may be attributed to its biological oxidation to sulphuric acid which reacts with $CaCO_3$ producing $CaSO_4$. The action of Ca^{2+} is mainly through exchange reactions with Na^{+}, where sulphuric acid acts directly through neutralization of Na_2CO_3 and indirectly through the formation of Ca SO_4 which reacts with sodic colloids. *(El-Gabaly, 1971)*.

The reduction in ESP values was more pronounced when sulphur mixed with organic manure. The presence of organic matter accelerates biological oxidation of sulphur and improves the physical and chemical properties of soil. These effects led to improve soil aeration and promote

the leaching of the salts. The same conclusions were reported by Ghazy, (1994), *Zein et al, (1996b)* and *Abed- Allah, (1998)*.

3- ***Soil reaction (pH)***:

Soil reaction (pH) values maybe one of the most important parameters, which help to predict the relative availability of most inorganic nutrients.

Results in Table (3) show that, soil pH values slightly decreased after application of different amendments. The soil pH was decreased from 8.21 and 8.46 (control) to 8.12 and 8.20 in surface and subsurface layer, respectively with sulphur after harvesting the first crop.

The soil pH values were gradually decreased with the time after harvesting the second and the third crop. The favorable effect of sulphur in reducing soil pH values may be due to the action of

acidity produced as a result of sulphur oxidation (*Mostafa et al, 1990*).

The data indicated that, the reduction in soil pH was more pronounced with organic manure mixed with sulphur. This reduction maybe due to decomposition of organic manures and production of organic acids. These results correspond to those reported by *Awad,(1991), Khalifa,et al. ,(1993)* and *Ghazy,(1994)*.

The slight decrease in soil pH of all treatments may be attributed to buffering capacity of alluvial soil to resist the change in soil pH caused by the acid produced from organic matter decomposition. This results are in agreement with those obtained by *Fresquez et al, (1990), Ali, (1995)* and *Abd-Allah, (1998)*.

4- ***Organic matter (OM)***:

Data in Table (3) reveal that soil organic matter content was slightly decreased with sulphur and it was gradually decreased by the time, this result maybe due to increase the activity of micro-organisms for oxidation of the initial organic matter in the soil and partially exhausted by plants. On the other hand, the soil organic matter content was increased with organic manure combined with sulphur. The increases were more pronounced with increasing the application rate of organic manure. The differences in the content of organic matter in the soil may be due to the differences in decomposition degree of the added organic manure. These results were similar to that reported by (*Awad, 1991, Ghazy 1994 and Abd Allah,1998*) .

Concerning the soil organic matter content after the second and third crops, data indicate that the values of soil organic matter content was decreased by the time because the decomposition of applied manure was increased with increasing decomposition period , temperature and microbial activities. The values of OM of the surface layers were higher than those of the deeper layers.

It can be concluded from the above results that, increasing the application rate of organic manures up to 22.5 ton/fed increased soil

organic matter content. Also, the residual effect of organic manures on soil organic matter is different due to their chemical composition and the degree of mineralization.

5- Content of Soil Sulphate ($SO_4^{=}$):

Data in Table (3) reveal that, there were considerable effects of the sulphur application on the formation of sulphate ions. The amounts of $SO_4^{=}$ was increased from 1.13 and 1.0 to 1.35 and 1.21 meq/100g soil in surface and subsurface layers, respectively due to addition of sulphur. On the other hand, the application of organic manure in presence of sulphur produced higher amounts of $SO_4^{=}$. The sulphate content in the soil was gradually decreased with the time, may be due to the leaching of $SO_4^{=}$ in drainage water and decreasing the amount of $SO_4^{=}$ released from organic manures in the later stages as well as the uptake of $SO_4^{=}$ ions by plants. These results were in good agreement with those obtained by *Bayoumi et al, (1985)*.

6- Available Macro Nutrients of Soil:

Data in Table (4) showed the effect of different sources of organic manures in presence of sulphur on the total nitrogen content, available phosphorus and potassium in the studied soil. Data show that total nitrogen in soil that received organic manure combined with sulphur was higher than untreated soil. The percentage of total nitrogen in soil was relatively higher with sewage sludge than with farmyard manures. Meanwhile, the total nitrogen content was slightly affected with the rates of organic manure in both soil depths.

The availability of P in the soil may be influenced by adding elemental sulphur and organic materials. The oxidation of elemental sulphur leads to formation of sulphuric acid which reacts with calcium phosphate increasing the availability of P. The organic acids, which result from the microbial decomposition of added organic matter may solubilize the insoluble phosphate forms by chelating action and lowering soil pH (*Stevenson, 1982*). The values of available P was slightly increased after harvesting the second crop, and then decreased after harvesting the third crop, may

be due to exhausting of the added sulphur by the time and rising the pH of the tested soil due to its buffering action.

Data in Table (4) show that values of available P was greatly increased with organic manure combined with sulphur. The effectiveness of different treatments can be arranged according to the following descending order: (S+ TSS > (S + FYM) > (S) > (Control). On the other hand, the highest values of available P were obtained with higher rate of added organic materials (22.5 ton / fad).

The organic matter definitely plays an active role in the availability of K+ in soil. Potassium releasing from non-exchangeable form takes place when the equilibrium between various forms is unbalanced. This may occur when the soluble and/or exchangeable forms of K are exhausted through plant absorption. (Abou Zeid et al, 1992).

Data in Table (4) show that the available K was increased from 410 to 434 and from 428 to 429 ppm in surface and subsurface soil, respectively as a result to addition of sulphur. This may be attributed to the increase of soil biological activities with sulphur application and consequent increase soil acidification and K availability. The values of available K were gradually decreased after harvesting the third crop, maybe due to decline the activity of S-oxidation micro-organisms by the time.

The effectiveness of sulphur was pronounced in plots treated with different sources of organic manure especially sewage sludge. The effects of different organic wastes on the availability of K in the tested soil were different and may be due to the differences in chemical composition and the decomposition rate of organic manure

II- Effect of Sulphur and Organic Manure on Crop Yield

1-Sugarbeet:

Data in Table (5) show that the addition of sulphur significantly increased the yield of roots and sugar. The yield of roots and sugar

were 24.22 and 4.14 tons/fad, respectively as a result of sulphur application compared with 20.35 and 3.15 tons/fad for roots and sugar yield, respectively with untreated soil. This effect maybe due to sulphuric acid which lower the pH and increases the availability of some nutrient elements and hence positively affected the crop yield. Also, the effect of sulphur in increasing yield of sugar beet might be attributed to increasing the depth of root zone resulting in higher uptake of nutrients and thereby increasing the vegetative growth and yield, (*Abd El-Fattah et al, 1990 and Abd-Allah, 1998*).

Concerning the combined effect of sulphur and organic manures on the yield of roots and sugar, data in Table (5) show that application of organic manures combined with sulphur produced higher amounts of roots and sugar compared with sulphur alone. The application of sewage sludge was more effective than farm yard manure on root yield. This maybe due to the high content of organic matter and low salinity of sewage sludge compared with farmyard manure.

2-***Seed melon***:

Data in Table (5) show that seed melon yield with sulphur was significantly increased over the control. The seed yield was increased from 305.0 to 391.0 kg/fad, and the percent of the increase was 28.38% over control. This may be due to that the residual effect of sulphur acts as an amendment for soil alkalinity and gradually decrease the ESP values. The results of the residual effect of organic manure combined with sulphur on seed melon yield are given in Table (5). These results indicate that there are significant increases in seed melon yield and the highest increase in yield were obtained by sewage sludge combined with sulphur where percent of increase was 38.79% over the control. On the other hand, effect of organic manure rates on seed yield was insignificant

Table (3): Effect of sulphur and organic manure on some chemical properties of tested soil after harvesting sugarbeet and the subsequent crops.

Treat. No.	Treatment	Soil depth cm	First crop (sugarbeet)					Second crop (seed melon)					Third crop (Egyptian clover)				
			pH1: 2.5	EC dS/m	ESP	O.M %	SO_4^{2-} meq/ 100g	PH 1:2.5	EC dS/m	ESP	O.M %	SO_4^{2-} meq/ 100g	PH 1:2.5	EC dS//m	ESP	O.M %	SO_4^{2-} meq/ 100g
1	Control	0 -30	8.21	5.48	26.75	0.75	1.13	8.32	6.12	27.81	0.58	1.00	8.55	7.80	28.04	0.69	0.8
		30-60	8.46	20.11	32.78	0.64	1.00	8.44	20.69	33.00	0.53	0.86	8.65	21.00	33.79	0.64	0.7
2	(S) alone	0 -30	8.12	4.83	18.47	0.58	1.35	8.03	4.76	15.01	0.51	1.20	7.91	4.05	14.63	0.50	1.0
		30-60	8.20	10.03	21.59	0.52	1.21	8.01	9.93	18.93	0.50	1.07	7.98	9.58	16.04	0.42	0.6
3	(S) + (TSS)I	0 -30	7.96	4.23	14.94	1.01	1.65	7.78	3.18	13.55	0.80	1.41	7.67	3.09	12.31	0.67	1.3
		30-60	7.98	8.21	19.02	0.98	1.59	7.96	7.44	16.09	0.41	1.20	7.35	7.13	14.65	0.40	0.9
4	(S)+ (TSS)II	0 -30	7.88	3.80	14.16	1.26	1.79	7.92	2.98	12.99	0.86	1.17	7.01	2.22	12.00	0.80	1.2
		30-60	8.07	7.64	19.00	0.78	1.40	7.88	7.34	16.90	0.63	1.15	7.85	7.05	15.01	0.61	0.8
5	(S) + (FYM)I	0 -30	8.06	4.76	16.96	0.98	1.58	7.63	4.14	14.36	0.75	1.13	7.43	3.79	12.83	0.70	1.1
		30-60	8.10	9.16	20.94	0.72	1.34	7.94	9.11	18.01	0.67	1.11	7.51	8.01	15.13	0.60	0.7
6	(S) + (FYM)II	0 -30	8.03	4.40	16.01	1.07	1.59	7.43	3.76	14.01	1.01	1.16	7.51	3.19	13.35	0.93	1.1
		30-60	8.03	8.68	20.41	0.98	1.44	7.73	8.58	19.80	0.73	1.10	7.72	8.27	15.00	0.70	0.8

Table(4): Total nitrogen, available P and K in soil as affected by organic manure in presence of sulphur after harvesting sugar beet and subsequent crops

Treat No.	Treatments	Soil Depth cm	Sugarbeet			Seed melon			Egyptian Clover		
			N %	*P* *ppm*	*K* *ppm*	*N* %	P ppm	*K ppm*	*N* %	P ppm	*K ppm*
1	control	0 -30	0.092	11.99	410	0.089	12.68	389	0.091	12.40	375
		30-60	0.087	9.66	428	0.082	10.06	403	0.083	9.71	400
2	(S) alone	0 -30	0.095	14.42	434	0.090	16.57	415	0.093	14.90	385
		30-60	0.087	9.89	429	0.081	10.71	409	0.084	10.25	401
3	(S) + (TSS)I	0 -30	0.137	28.88	529	0.123	33.88	476	0.110	29.58	426
		30-60	0.092	12.51	431	0.084	12.26	412	0.086	12.21	416
4	(S)+ (TSS)II	0 -30	0.165	35.20	536	0.148	38.30	465	0.099	32.63	441
		30-60	0.094	12.12	438	0.091	12.25	410	0.085	11.56	419
5	(S) + (FYM)I	0 -30	0.112	26.38	512	0.095	32.07	453	0.095	27.42	419
		30-60	0.090	12.03	433	0.083	11.81	408	0.087	11.64	407
6	(S) + (FYM) II	0 -30	0.129	31.16	518	0.108	33.61	446	0.091	29.02	428
		30-60	0.091	11.61	435	0.084	11.96	406	0.084	11.69	413

Table(5): Effect of Sulphur and Organic Manure Applications on Yield of Sugarbeet and Subsequent Crops

Treat No	Treatments	Sugarbeet				Seed Watermelon		Egyptian Clover		
								Total Yield		Dry matter Increase %
		Root Yield ton/fad	Sucrose%	Gross Sugar ton/fad	Sugar Increase%	Seeds kg/fad	Percent of increase	*Fresh ton/Fad*	*Dry ton/fad*	
1	**control**	20.35d	15.5de	3.15b	0.0	305.00	0.0	39.30	6.51	0.0
2	**(S) alone**	24.22c	17.1a	4.14a	31.40	391.56	28.38	47.90	8.73	34.1
3	**(S) + (TSS)$_I$**	27.84a	15.5e	4.32a	37.14	423.31	38.79	49.56	10.07	54.69
4	**(S) + (TSS)$_{II}$**	26.82ab	15.1e	4.05a	28.57	417.75	36.97	48.28	9.62	47.77
5	**(S) +(FYM)$_I$**	25.83abc	16.4cd	4.24a	34.60	415.02	36.08	48.18	9.37	43.93
6	**(S) +(FYM)$_{II}$**	25.13bc	16.0cde	4.02a	27.62	411.05	34.77	47.53	9.16	40.71
	L.S.D. 0.05	2.075	0.562	0323		20.472				
	0.01	2.801	0.960	0436		27.65				

3-*Egyptian Clover*:

Data of the residual effect of sulphur alone or mixed with organic manures on the dry matter of clover (sum of 3 cuts) are given in Table (5). The dry yield with sulphur was clearly increased over the control by 34.1%.

The residual effect of sulphur in soil can be extended over five successive agriculture seasons and the increase in crop production depend upon the rate of added sulphur (*Hilal, 1990*).

The results of the residual effect of organic manures combined with sulphur on yield of clover show that the yield was generally increased over the control. The highest dry weight was obtained with sewage sludge where dry matter was increased by 54.69% over the control and by about 9% over the yield obtained by farm yard. These differences of the residual effects of organic materials maybe due to their chemical composition , degree of decomposition and their pH which impact on the availability of the nutrients in soil (*Hassanien et al , 1992* and *Abd-Allah, 1998*).

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الملخص العربي

تأثير بعض المصلحات على تحسين الأراضي المتأثرة بالأملاح

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أجريت هذه الدراسة في أرض ملحية قلوية في قطاع الحامول بمحافظة كفر الشـيخ في ثلاث مواسم متعاقبة ١٩٩٩/ ٢٠٠٠ ،٢٠٠٠، ٢٠٠٠/٢٠٠١ وذلك بغرض دراسة تأثير الكبريت (١,٤ طن/فدان) منفردا أو مخلوطا مع المواد العضـوية(١٥,٠ ، ٢٢,٥ طن/فدان من حمأة المجارى المعالجة أو سماد المزرعة)على بعض الخواص الكيميائية للأراضي المتأثرة بالأملاح و كذلك على محصول بنجر السكر و المحاصيل التالية لـه مثل بطيخ اللب و البرسيم المصري .

انخفضت قيم الملوحة في التربة عقب حصاد المحصول الأول (بنجر السكر) نتيجة إضافة الكبريت منفردا أو مخلوطا مع المواد العضوية وقد استمر الانخفاض فـي قـيم الملوحة بزيادة زمن التجربة (عقب المحصول الثانى و الثالث).

انخفضت قيم pH ، ESP في التربة في القطع المعاملة بالكبريت مقارنـــة بـــالقطع الغير معاملة وكان الانخفاض أكثر عند خلط الكبريت مع المواد العضوية خاصة حمـــأة المجارى المعالجة و قد تأثر الانخفاض تدريجيا بالزمن ومعدل الإضافة.

انخفض محتوى التربة من المادة العضوية عند إضافة الكبريت على حدة و لكن زاد هذا المحتوى مع إضافة الكبريت مع المواد العضوية و خاصة مع الحمأة.

زاد محتوى التربة من الكبريتات مع مختلف المعاملات و أن كانـــت هـــذه الزيـــادة واضحة في حالة خلط الكبريت بالمواد العضوية.

إضافة الكبريت مخلوط مع المواد العضوية أدى إلى زيادة الميســـر مـــن عناصـــر النيتروجين والفوسفور و البوتاسيوم و خاصة عند خلط الكبريت مع ٢٢,٥ طـــن مـــن حمأة المجارى المعالجة.

زاد محصول الجذور و كذا السكر في محصول بنجر السكر زيادة معنويـــة نتيجـــة إضافة الكبريت مقارنة بالأرض الغير معاملة. و كانت أعلى القيم عند خلط الكبريـــت مع المواد العضوية خاصة حمأة المجارى المعالجة.

زادت كمية لب البطيخ في الموسم الثاني و كذا محصول البرسيم (الوزن الطازج و الوزن الجاف) في الموسم الثالث نتيجة للأثر المتبقي مع خلـــط الكبريـــت مـــع المـــادة العضوية خاصة حماة المجارى.

Impact of Different Sources and Methods of Irrigation on Productivity of Maize and Cotton at North Dlta.

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ABSTRACT

Two field experiments were conducted at Sakha Agric.Res. Station Farm during summer season of 2000 to investigate the effect of different water resources i.e, fresh water, drainage water and contaminated drainage water used as continuous or alternative with fresh water under two methods of irrigation ;surface and drip on maize and cotton yields, water relations, soil salinity and the elemental contents of soil and plant. Results indicated the superiority of drip irrigation method over surface irrigation. The maize grain yield was increased by 17.72 and 17.58%, as a result of irrigation with continuous use of contaminated drainage and agricultural drainage water, respectively. While seed cotton yield was increased by 14.26 and 9.0% under irrigation by continuous and alternative contaminated drainage with fresh water, respectively, compared to fresh water.

Drip irrigation method resulted in higher water application and distribution efficiencies. Also, maximum crop and field water use efficiencies of the two crops were realized with alternative use of agricultural drainage with fresh water, as compared to surface irrigation method .

Salt accumulation in soil after harvesting of cotton and maize crops were more pronounced with agricultural drainage and contaminated drainage water under drip irrigation method .

Concerning the available contents of macro and micro-nutrients in soil and plant, data revealed that a relatively high content of these elements were achieved with low quality water, but they are still under the permissible limits.

Key words: Water quality, irrigation methods, irrigation efficiencies, and elemental contents.

INTRODUCTION

The needed increase in food production to support the acceleration of population growth in Egypt (2.7%), compels the country to use all sources of water i.e. drainage water, ground water and treated wastewater, FAO, (1992). Four billion m3 of drainage water presently reused in irrigation in the Delta which expected to increase gradually to reach 7.7 billion m3 by the year 2010. It is to be noticed that part of this water is from industrial and municipal waters discharged to the drainage system (Abu – Zeid, 1995). Farmers at the tail-end of the irrigation canals unofficially reuse about 2 billion m3/yr. of drainage water directly for irrigation ; whenever they suffer from limited canal water supply (EL-Hessy and EL- Kady , 1997).

Under normal conditions, the type of irrigation methods selected will depend on water supply conditions, climate, soil, crops to be grown, cost of irrigation method and the ability of farmer to manage the system, FAO (1992).

Hanson and Patterson (1974) compared the effects of trickle, furrow and sprinkler systems on water use efficiency and yield of sweet corn (Zea mays L) Corn yield was the same for trickle and furrow methods, while water use efficiency was higher for trickle and sprinkler systems. El-Mowelhi, et al (1999) reported that the highest values of crop and water use efficiencies were 1.67 and 1.65 kg maize grain yield /m3 of water consumed or m3 of water applied, respectively, with drip irrigation system.

Rhoades (1984) reported that a good cotton seed yield was obtained by plant establishment with that a good quality water and subsequent with saline water. Hodgson et al (1990) reported that the water use efficiency of cotton was 16% higher under drip than furrow irrigation when supply channel asses and runoff losses in furrow were considered.

Goda , (1984) found that , the high water use efficiency is accompanied by high yield per unit area under drip irrigation system . Aronaout (1997) found that irrigation efficiency of drip system increased by (15.8%) and (38.2%) more than irrigation efficiency of sprinkler and furrow systems , respectively.

Mostafa et al (1992) and Amira (1997) found that increasing salinity level in drainage water seems to increase soil salinity level on the investigated soil.

Selem et al,(1989) and Hegazi ,(1993) reported that, both total and available N,Pand K were increased in soils which irrigated by the Nile water mixed with drainage water or sewage effluents. Hegazi ,(1999) found that the magnitude of enriching soils with macro &micro-nutrients or non-nutritive heavy metals was increased by increasing the period of irrigation with drainage or sewage effluents .

The objective of this study was to investigate the effect of different water sources under two methods of irrigation on maize and cotton yields, water relations, soil salinity and the elemental contents of soil and plant.

MATERIALS AND METHODS

An area of about 5 feddans of clayey soil has been selected at Sakha Agricultural Research Station Farm during summer season 2000. The experimental area was divided into sub-experimental areas (No. 1 and No. 2) .The first area No. 1 was cultivated by maize(C.V. T.W C 323) using manual planting on a dry soil on the 20th of June and harvesting took place on the 27th of October. At harvesting time, grain yield (15% moisture), were recorded as ardab/fed. While the 2nd area cultivated by cotton (Var. Giza 86) was planting on the first of April and picking was done twice after 180 and 205 days from soaking . Seed cotton yield was recorded as kentar/fed. For each crop all recommended agronomic practices were applied for all the experimental plots.

A split plot design with four replicates was used, where the main plots, were assigned to the different water sources; i.e, (W1) Nile water with EC of about 0.53 dS/m for all irrigations., (W2) Agricultural drainage water with EC= 1.25dS/m for all irrigations, (W3) contaminated Agricultural drainage water with EC= 1.55dS/m for all irrigation, (W4) :cyclic irrigation with (W1) and (W2) starting with (W1) and (W5) , cyclic irrigation with(W1) and (W3) starting with (W1). While the methods of irrigation i.e. surface irrigation and drip irrigation were located in the subplots.

All data were statistically analyzed according to Snedecor and Cochran,(1967) .Some physical properties of soil were determined Table (1) according to Black (1982). The chemical composition of water sources was done according to the standard .Procedure as described in Richards (1969) and shown in Table (2).

Table (1) some physical properties of different soils.

Locations	Particle size distr. (%)			O.M %	$CaCO_3$ %	Texture class	Bulk density g/cm3	Moisture%		
	Sand	Silt	Clay					F.C	W.P	A.W
Exp. (1)	19.20	34.0	46.8	1.30	3.80	Clayey	1.27	39.8	20.3	19.5
Exp. (2)	18.70	32.5	48.8	1.10	2.80	Clayey	1.30	41.2	22.0	19.2

Table (2) Chemical properties of different water sources

Water sources	EC dS/m	SAR	Ppm									
			P	Zn	Mn	Fe	Cu	Cd	Pb	Co	B	Cr
W1	0.53	1.48	0.32	00	0.055	0.025	0.008	0.007	0.032	0.02	0.06	0.03
W2	1.25	4.65	4.85	0.09	0.945	0.331	0.019	0.055	0.041	0.016	0.21	0.06
W3	1.55	3.95	0.42	0.01	0.028	0.213	0.009	0.002	0.084	0.004	0.01	0.03

Water relations:

Irrigation water applied was determined using a flow meter for drip irrigation and is based on the compensating the cumulative of evaporated water from Class A Pan between each two irrigations and crop coefficient (Doorenbos and Pruitt, 1984), Table (3) and using a set of cut-throat flume (30 × 90 cm) for surface irrigation according to , Early (1975).

Table (3) Meteorological data of Sakha Agriculture Research station in the 2000 season

Months	*Temp. (c^0)*			*Relative humidity %*	*Wind speed Km/ day*	*Solar Radiation Cal/cm²/ day.*	*Evaporation Cm/ day*
	Max	*Min*	*Mean*				
April	***26.4***	***12.4***	***19.4***	***57.3***	***155.52***	***420.03***	***0.51***
May	***30.62***	***16.2***	***23.14***	***60.3***	***107.4***	***440.43***	***0.69***
June	***31.2***	***18.2***	***24.7***	***57.7***	***172.3***	***566.4***	***0.69***
July	***31.6***	***21.3***	***26.45***	***69.8***	***143.5***	***575.2***	***0.81***
August	***32.2***	***23.1***	***24.65***	***69.5***	***96.6***	***588.6***	***0.71***
Sep.	***32.2***	***18.8***	***25.5***	***62.4***	***83.4***	***586.5***	***0.61***
Oct.	***25.78***	***11.62***	***18.52***	***57.6***	***158.32***	***299.73***	***0.39***

Actual water consumptive use: was computed as the differences in soil moisture content according to the following equation: (Israelsen and Hansen, 1962).

$$CU = \frac{(\varnothing_2 - \varnothing_1)}{100} \times B.d \times D$$

Where:

Cu: water consumptive use in cm

ø 2: Soil moisture % after irrigation

ø 1: Soil moisture % before the next irrigation

Bd: Soil bulk density g/cm^3

D : Soil depth in cm

Water application efficiency (WAE): was calculated using the following equation (Downey, 1971)

WAE =water consumptive use (cm) / water delivered to the field plot (cm) x100

water distribution efficiency (Ed): Ed = (1- y/d) X 100 (Michail,1978)

- Crop water use efficiency (CWUE):

CWUE= Yield (kg/fed.) / Seasonal water consumptive use (m^3/fed.) (Michail, 1978)

Field water use efficiency (FWUE):

FWUE = yield (kg/fed.) / amount of water applied (m^3/fed.) (Michail, 1978)

Before planting and after harvesting of the two crops, soil samples were taken from each treatment for chemical analysis (ECe dS/m and soluble ions in soil paste extract) according to Black (1982).

Soil available nitrogen was extracted by K_2SO_4 solution 0.5 N and determined using Automatic micro-kjeldahl. Soil available P was extracted by NaHCO3 0.5 N and determined according to Murphy and Riley (1962) .soil available k was extracted by ammonium acetate 1N and determined using the flame photometer according to page (1982)

Available content of trace elements in soil samples were estimated according to the method of Lindsay and Norvell (1978) using atomic absorption spectrophotometer.

Plant samples were digested by HCLO4 and H_2SO_4 to determine Fe, Mn, Zn, Cu, Cd, Pb, and Co and measured by inductively coupled plasma Emission Spectrophotometer.

RESULTS AND DISCUSSION

1 Yield of Maize and Cotton Crops:

1.1 Maize grain yield:

Maize grain yield (ardab/fed.) as affected by different water sources and methods of irrigation are illustrated in Table (4). Data reveal that, there was a significant effect of water sources on maize grain yield .The highest yield (23.42 ardab/fed) was achieved with using W3 followed by W2 treatment (23.38 ardab/fed). While, the lowest value of grain yield (19.27 ardab/fed) was obtained with water source W1. This may be due to the increase of macro and micro nutrients in water sources W2 and W3, as well as the low salinity of these waters . It can be concluded that, maize grain yield under both W2 and W3 were surpassed W1 by about 17.72% and 17.58%, respectively. Different irrigation methods reveal a significant effect on maize grain yield . Where drip was surpassed surface irrigation method by 6.38%.These results were similar to those obtained by Hegazi (1993) and EL-Mowelhi et al (1999). The interaction between water sources (W) and irrigation methods (I) was not significant for maize grain yield.

1.2 Seed cotton yield:

Results of seed cotton yield (kentar/fed.) as affected by water sources and methods of irrigation are presented in Table (4). Data reveal a significant effect on seed cotton yield due to different water sources. The highest yield (8.59and 8.1 Kentar/fed.), were obtained by using W3 and W5 treatments, respectively. While, the lowest value (7.17%) by W2. These results may be attributed to the higher content of macro and micro nutrients in water source W3. Concerning the effect of irrigation methods, data in Table (4) show that a significant effect on seed cotton yield. Drip irrigation surpassed surface irrigation method which it recorded the highest values of cotton yield (7.93 kentar/fed). The interaction between different water sources and methods of irrigation was significant.

Table (4) Maize grain yield, seed cotton yield and relative change (± %) as affected by different treatments.

Treatments	Maize grain yield ardab/Fed.	Relative change of yield (± %)	Seed cotton yield kentar/fed.	Relative change of yield (± %)
Water Sources (W):				
W1	19.266		7.363	
W2	23.376	17.58	7.171	-2.68
W3	23.416	17.72	8.588	14.26
W4	23.282	17.25	7.414	0.69
W5	22.512	14.42	8.091	9.00
1.2.1.1 F- Test	**		**	
0.05	0.067		0.055	
0.01	0.096		0.073	
Irrigation methods (I):				
Drip	23.060	6.38	7.925	6.94
Surface	21.676		7.411	
F- Test	**		**	
Interaction W × I	Ns		*	

W1:Fresh water ,W2: Drainage water (main drain) ,W3: Drainage water (sub-drain), W4:cycles of W1 and W2 and W5: cycles of W1 and W3

2 Water relations: -

The actual water consumptive use, amount of irrigation water applied, water application, water distribution efficiencies and field and crop water use efficiencies as affected by different water sources and methods of irrigation for maize and cotton crops are presented in Tables (5 and 6)

2.1 Amount of irrigation water applied:

Data in Table (5) showed that, the highest amount of water applied for maize crop was found with using water sources W3 and W5 under both methods of irrigation, While, the less amount of water applied achieved by using water sources W2 and W4, under drip method, which saved 15.37% as compared to surface irrigation method. The decrease of water requirement under drainage water in comparing to fresh water, may be attributed to increase the osmotic pressure with decreasing available water.

Concerning cotton crop, the results clearly indicate that drip irrigation method saved water by 12.74% as compared to surface irrigation

. Also, data show that water source (W1) treatment received the highest amount of water applied under different methods of water application. On the other side, water source (W2) received the lowest amount of water applied.

It was noticed that, drip method, under maize crop saved irrigation water by 20.31 and 17.51%when using water sources W3 and W1, respectively as compared to the surface method. While the corresponding values of cotton crop (14.49 and 14.61%), respectively were recorded under the same water sources.

2.2 Actual water consumptive use :

Data of actual water consumptive use of maize as affected by different treatments are presented in Table (5): under surface irrigation, the highest value was recorded by water source (W1), whereas, the lowest one was obtained by water source (W2). While, under drip irrigation, using water source W3 achieved the highest value, where, W2 recorded the lowest one. Moreover, drip irrigation method consumed water less than surface irrigation.

Table(5): Actual water consumptive use, amount of irrigation water applied, water application and water distribution efficiencies as affected by different water sources under methods of irrigation for maize and cotton crops.

Water sources	Actual water Consumptive use m^3/fed.		Amount of water Applied m^3/fed.			Water Application efficiency %		Water distributio efficiency %	
	Surface	*Drip*	*Surface*	*Drip*	*Water Saving %*	*Surface*	*Drip*	*Surface*	*Drip*
					Maize				
W1	2075.64	1678.74	2334.89	1925.99	17.51	83.19	89.74	91.55	96.35
W2	1859.34	1602.3	2264.97	1904.71	15.91	76.23	84.88	90.99	97.32
W3	2028.6	1803.06	2504.92	1996.16	20.31	84.81	87.85	90.36	95.11
W4	1916.88	1682.94	2177.74	1939.33	10.95	80.92	84.25	86.46	92.61
W5	2026.08	1649.34	2313.93	2031.9	12.19	87.16	87.94	90.4	94.78
Mean	1981.31	1683.28	2319.29	1959.62	15.37	82.462	86.93	89.952	95.234
					Cotton				
W1	2584.3	2427.6	3240.5	2767	14.61	79.75	87.73	90.9	98.3
W2	2398.2	2304.5	2912.5	2592	11.0	82.34	88.91	88.5	95.47
W3	2628.8	2362.1	3054.8	2612	14.49	86.05	90.43	89.9	95.1
W4	2483.9	2373.0	2998.5	2706	9.75	82.84	87.69	89.9	95.99
W5	2651.0	2420.5	3123.3	2691	13.83	84.88	89.94	90.1	94.9
Mean	2549.24	2377.54	3065.92	2674	12.74	83.172	88.94	89.86	95.952

Concerning cotton crop, it could be noticed that the actual water consumptive use increased with surface irrigation compared to drip irrigation by 6.74%. Also, data revealed that the irrigation by water source (W5) under surface irrigation recorded the highest value (2651 m3/fed.), while the lowest value (2398.2 m3/fed.) was recorded by irrigation with water source (W2). The same trend was obtained under drip irrigation.

2.3 Water application efficiency:

From Table (5) data show that the water application efficiency with drip irrigation exceeded surface irrigation method by 5.6%. The highest value for maize crop was achieved with W1 under drip irrigation method. While, the lowest value was obtained with W2 under surface irrigation. This due to great losses under surface irrigation .

For cotton crop, data reveal that the highest value of water application efficiency was achieved with W3 under drip irrigation. While, using W1 under surface irrigation recorded the lowest value.

2.4 Water distribution efficiency:

From Table (5). The uniformity of water applied describes water distribution either of emitter's discharge along the laterals or along individual furrows. The drip method surpassed surface irrigation method, which achieved the highest values of water distribution efficiency under different water sources for maize crop.

With regard to cotton crop, the values of water distribution efficiency took the same trend as maize crop. However the highest value (98.3%) was obtained with using W1 under drip method, while , the lowest value (88.3%) was achieved with using W2 under surface method. This due to the variation in water stored depth along the irrigation run length as a result of irrigation with under surface irrigation.

2.5 Crop and filed water use efficiencies:

From data listed in Table (6) it could be noticed that, the highest value (1.98 and 1.72kg/m^3) of crop and field water use efficiencies for maize under drip irrigation method, was achieved by using W4, whereas, the lowest values(1.34 and 1.91kg/m^3) were obtained by using (W1) under surface irrigation Respecting to cotton crop, using W3 achieved the highest value (0.58 and 0.52kg/m^3) of crop and field water use efficiencies under drip irrigation while, irrigation by W1 realized the lowest one (0.44 and 0.35kg/m^3) under surface irrigation method.

Table (6): Crop and field water use efficiencies of maize (kg/ m^3) as affected by different water sources and methods of irrigation.

Water sources	Maize				Cotton			
	Crop water use efficiency (kg/ m^3)		Field water use efficiency (kg/ m^3)		Crop water use efficiency (kg/ m^3)		Field water use efficiency (kg/ m^3)	
	Surface	Drip	Surface	drip	Surface	drip	surface	drip
W1	1.34	1.56	1.19	1.36	0.44	0.48	0.35	0.42
W2	1.9	1.88	1.56	1.59	0.44	0.52	0.36	0.46
W3	1.72	1.69	1.4	1.53	0.5	0.58	0.43	0.52
W4	1.64	1.98	1.45	1.72	0.46	0.49	0.38	0.43
W5	1.56	1.91	1.36	1.55	0.45	0.55	0.38	0.5

3 Soil salinity and salt balance:

The rate of change of ECe and SARe for experimental areas as affected by different water sources for maize and cotton are listed in Table (7). Data revealed that using W2 under surface irrigation tend to increase soil salinity (+ 1 0 and +1.76 dSm/1)and SARe (0.9 and 1.4) for maize and cotton, respectively . On the other hand, using W1 tend to decrease soil salinity (-0.17 and -0.08 ds/m) for both crops ,respectively. While using W3 slightly increase soil salinity (+0.2 and + 0.75 dS/m) and SARe (0.41 and 1.21) , respectively for both crops under the same methods of irrigation. Using W4 or W5 lead to decrease their values of ECe and SARe .Similar results were obtained by **Mostafa et al (1992) and Amira (1997).**

Concerning drip irrigation method, data in Table (7) confirmed the same trend previously detected for maize and cotton. In consequence, using W1 for irrigation slightly lowered soil salinity (-0.25 and -0.1dS/m) for both crops respectively, while the maximum increase in ECe values were resulted with using W2 .

Generally, it could be noticed that salt accumulation after harvesting of maize is lower than those after cotton crop may be due to the season length and difference in water amount received by crop.

Table (7) Salt balance after harvesting of maize and cotton crops as affected by different water sources and methods of irrigation

Water Source	**Surface irrigation**						**Drip Irrigation**					
	Before		**Maize**		**Cotton**		**Before**		**Maize**		**Cotton**	
	ECe dS/m	SARe	ECe dS/m	SARe	ECe dS/m	SARe	ECe dS/m	SARe	ECe dS/m	SARe	ECe dS/m	SARe
W1	1.49	6.6	-0.17	+0.6	-0.08	+0.8	2.65	9.56	-0.25	+0.29	-0.1	-0.20
W2	1.64	7.5	+1.01	-0.9	+1.76	+1.4	3.49	9.91	+1.21	+1.4	+1.41	+1.8
W3	2.25	8.19	+0 20	+0.41	+0.75	+-1.21	4.44	10.5	+0.46	0.8	+0.66	+1.1
W4	2.38	8.30	+0.46	+0.7	+1.012	+1.0	3.07	9.97	+0.63	+0.23	+0.88	+0.91
W5	2.14	8.12	+0.16	+0.21	+0.46	+1.18	2.57	9.56	+0.33	+0.32	+0.73	+0.8

4 Elemental content of soil and plant as affected by water sources and methods of irrigation.

4.1 Soil elemental content:

The content of available macro and micro elements of soil after maize and cotton as affected by different water sources and methods of irrigation are listed in Tables (8 and 9). Data indicated that, macro-nutrients content were appreciably increased with all water sources over their values before experiment except N with water source W1, that slightly decreased. The lowest content of macro nutrients in soil were obtained by using water source W1 either continuously or alternatively with W2, while the highest values were achieved with water source W3 followed by W2 under the two irrigation methods. Surface and drip irrigation had a little effect on soil macro-nutrients after harvesting of cotton and maize crops. It could be observed that nitrogen content after maize crop were lower than those detected after cotton crop under both methods of irrigation that may be due to the ability of maize crop to utilize more nitrogen than cotton.

With regard to micro-nutrients, soil contents of Zn, Mg, and Co after harvesting of both crops, were obviously increased compared to those before experiment. While, the contents of Fe, Pb and B were decreased Also, the content of Cu and Cr were slightly increased by W3 under both methods of irrigation.

Soil micronutrients content were under the permissible levels according to National Academy of Science (1972). It can be concluded that irrigation with W3 and W2 enriched the soil with macro-and micro-elements. These results may be due to the high content of these elements in this water. These results were similar to those obtained by El-Wakeel and El- Mowelhi(1993) and Hegazi (1999).

4.2 Plant elemental Content:

It could be noticed from data listed in Tables (10 and 11) that elemental content of maize and cotton plants irrigated by water source W3 were slightly increased than other treatments. This increase was more pronounced in maize grains; this may be due to the enrichment soil with nutrient elements, and as mentioned before, to the ability of maize crop to utilize more nutrient . It was noticed that, the elemental content in both crops under drip irrigation were higher than their contents under surface irrigation.

Generally, it could be concluded that the level of heavy metals in soil and plant were under toxic limits according to the National Academy of Science (1972).

Table (8): Soil elemental content (ppm) as influenced by different treatments after maize

Water	N	P	K	Fe	Zn	Mn	Co	Cd	Pb	Cu	B	Cr
Before exp.	30.5	5.6	320	15	2.1	15.3	0.3	0.3	2	2.9	3.75	0.3
After surface irrigation												
W1	28.5	7.4	350	14.8	2.20	16.4	0.32	0.30	1.61	2.40	3.2	0.31
W2	32.1	11.0	385	17.2	2.80	17.1	0.38	0.35	1.68	2.55	3.60	0.33
W3	36.4	12.5	410	18.8	3.00	18.5	0.42	0.37	1.72	3.85	3.85	0.35
W4	30.5	9.5	365	15.0	2.30	16.2	0.35	0.30	1.58	2.50	3.30	0.31
W5	31.2	10.5	370	16.0	2.40	16.8	0.36	0.31	1.60	2.60	3.55	0.34
After drip irrigation												
W1	27.8	7.10	340	14.4	2.00	15.5	0.32	0.30	1.40	2.35	3.00	0.29
W2	31.6	10.7	370	16.8	2.55	16.2	0.37	0.35	1.58	2.50	3.00	0.30
W3	34.1	12.0	380	18.0	2.70	16.8	0.41	0.36	1.62	3.40	3.62	0.33
W4	29.8	9.30	358	14.9	2.27	15.8	0.35	0.30	1.50	2.40	2.90	0.30
W5	30.1	10.1	362	15.7	2.35	16.0	0.36	0.31	1.53	2.50	3.00	0.31

Table (9) Soil elemental content (ppm) as influenced by different treatments after cotton

Water sources	N	P	K	Fe	Zn	Mn	Co	Cd	Pb	Cu	B	Cr
Before exp.	30.5	5.6	320	25	2.1	15.3	0.3	0.3	2	2.9	3.75	0.3
After surface irrigation												
W1	30.5	8.5	380	15.7	2.15	16.6	.35	0.31	1.55	2.45	3.2	0.31
W2	36.3	12.0	480	18.1	2.82	17.5	.41	0.35	1.65	2.35	3.65	0.32
W3	38.5	14.0	420	19.42	3.1	18.9	.44	0.38	1.74	3.85	3.88	0.35
W4	33.5	11.0	410	15.5	2.35	16.9	.38	0.3	1.59	2.39	3.32	0.31
W5	35.1	11.5	400	16.5	2.5	17.1	.39	0.32	1.62	2.32	3.52	0.34
After drip irrigation												
W1	30.2	8.2	354	15.2	2.1	15.8	0.33	0.3	1.45	2.18	3.1	0.29
W2	35.2	11.8	465	17.8	2.65	16.5	0.39	0.36	1.58	3.2	3.1	0.29
W3	36.2	13.5	415	18.2	2.9	17.2	0.42	0.38	1.66	3.45	3.67	0.32
W4	32.5	11.0	395	16.1	2.3	15.4	0.36	0.33	1.50	2.85	2.8	0.3
W5	33.5	11.2	390	16.8	2.45	16.3	0.35	0.34	1.58	2.9	2.85	0.31

Table (10) Maize elemental contents as affected by different Water sources and methods of irrigation

Water Sources	*N*	*P*	*K*	*Fe*	*Zn*	*Mn*	*Co*	*B*	*Cd*	*Pb*	*Cr*	*Cu*
	%			p.p.m								
Surface irrigation												
W1	1.1	0.29	0.6	371	21.17	21.3	2.9	8.5	0.03	2.3	0.8	6.33
W2	2.1	0.45	0.82	542.1	38.33	40.3	3.7	14.5	0.07	3.3	1.5	11.6
W3	2.3	0.47	0.95	591	50.17	44.1	4.6	15.5	0.08	3.9	1.9	13.5
W4	2	0.38	0.8	515	32.5	33.5	3.1	14.5	0.05	2.9	1.2	11.5
W5	2.22	0.42	0.85	579	45.83	41.2	4.2	14.6	0.07	3.4	1.6	13.4
Drip irrigation												
W1	1.1	0.29	0.55	361	19.17	17.5	2.3	8.5	0.02	2.1	0.9	9.33
W3	2.9	0.45	0.88	595	58.17	36.2	3.4	15.8	0.05	3.9	1.8	15.17
W5	2.7	0.42	0.82	525	48.5	34.7	3.2	13.4	0.04	3.6	1.6	15
W2	2.6	0.44	0.81	462	41.5	35	2.8	13.1	0.04	3.3	1.55	14.17
W4	2.3	0.31	0.75	422	42.3	30.8	2.3	11.6	0.03	2.5	1.45	14.3

Table (11) Cotton elemental contents as affected by different Water sources and methods of irrigation

Water Sources	*N*	*P*	*K*	*Fe*	*Zn*	*Mn*	*Co*	*B*	*Cd*	*Pb*	*Cr*	*Cu*
	%			p.p.m								
Surface irrigation												
W1	0.87	0.87	0.65	354	35	12.5	1	12.5	0.025	1.1	1.1	7.5
W3	2.1	0.85	0.92	574	68	20	3.5	26.5	0.075	4	1.6	19
W5	1.85	0.82	0.88	545	66	13.5	3.2	24.5	0.062	3.5	1.55	18
W2	1.73	0.8	0.85	519	65	12.5	3.2	23.6	0.05	3.4	1.4	17.9
W4	1.6	0.75	0.81	514	62.5	11.5	31	21.5	0.045	3.1	1.3	17.3
Drip irrigation												
W1	1.55	0.7	0.7	322	33	11	0.8	14.5	0.022	0.9	0.9	7.4
W2	1.65	0.85	0.84	503	6.25	15.3	3.13	23.9	0.042	2.6	1.3	17.3
W3	1.85	1.2	0.85	531	66.5	18.8	3.4	24.5	0.055	4.3	1.4	17.6
W4	1.61	0.8	0.72	470	60.5	13.5	3	19.5	0.042	2.3	1.1	17.1
W5	1.75	0.9	0.84	5325	62.5	16.5	3.19	23.2	0.045	4.1	1.3	17.5

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الملخص العربي

تأثير مصادر مياه مختلفة وطرق الري علي إنتاجية الذرة والقطن في شمال الدلتا

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أقيمت تجربة حقلية في موقعين بمزرعة محطة البحوث الزراعية بسخا خلال الموسم الصيفي 2000 وزرع الموقع الأول بمحصول القطن والموقع الثاني بمحصول الذرة لدراسة تأثير مصادر مختلفة النوعية من مياه الري تحت نظامي الري السطحي والتنقيط علي المحصول، بعض العلاقات المائية ، ملوحة التربة ومحتوي التربة والنبات من العناصر الكبرى والصغري . وصممت التجربة بنظام القطع المنشقة مرة واحدة في أربعة مكررات حيث وضعت مصادر المياه في القطع الرئيسية وهي الري المستمر (مياه النيل ، مياه الصرف الزراعي ، مياه الصرف الزراعي الملوث) والري التبادلي بين (مياه الصرف الزراعي وكذلك الصرف الزراعي الملوث) مع مياه النيل كما وضعت طرق الري (السطحي ، التنقيط) في المعاملات الشقية .

وقد أوضحت النتائج :

- زيادة محصول حبوب الذرة باستخدام مياه الصرف الزراعي الملوث والصرف الزراعي بمعدل 17.72 ، 17.85 % علي الترتيب وكذلك تفوقت طريقة الري بالتنقيط علي الري السطحي .
- كما تظهر النتائج أن الري المستمر بمياه الصرف الزراعي الملوثة او الري التبادلي مع ماء النيل أدى إلى زيادة قدرها 14.26 ، 9.0% علي الترتيب في محصول القطن الزهر وعلي النقيض من ذلك أن الري المستمر بمياه الصرف الزراعي أدى إلى نقص في المحصول 2.68%
- أدى استخدام مياه الصرف الزراعي الملوث او الصرف الزراعي إلي زيادة محتوي كل من النبات والتربة من العناصر الكبرى تحت نظم الري المختلفة كما زادت العناصر الصغرى ولم تصل الي مستوى السمية للنبات
- أدى نظام الري بالتنقيط إلى توفير 15.37% من مياه الري المضافة وأيضا زيادة كفاءات الري المختلفة مقارنة بالري السطحي .زاد تراكم الأملاح في التربة بعد حصاد محصول القطن مقارنة بمحصول الذرة وهذا راجع للاختلاف كميات مياه الري المضافة كما زادت أيضا تحت نظام الري بالتنقيط مقارنة بالسطحي

Preliminary Guideline for Yield Response to Salinity and Sodicity of Irrigation Water Under North Nile Delta Conditions

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ABSTRACT

Preliminary Guideline of tolerance of soybean, canola, sunflower, cotton and sugarbeet crops to salinity and sodicity of irrigation water were introduced through long term lysimeter experiments in sand culture under North Delta climatic conditions. Linear equation of different crops indicate that, the relative yield decrement % with increasing unit of ECw were 16.02, 14.59, 13.88, 6.44 and 5.37 % for sunflower, canola, soybean, cotton and sugarbeet, respectively under SAR 10. Also, increasing the SAR of irrigation water increased the adverse effect of EC_w on the crop yield. The crops under consideration could be arranged in the following descending order, according to their tolerance to salinity of irrigation water.

Sugarbeet >Cotton > Soybean > Canola > Sunflower.

The multiple regression equations described the combined effect of EC_w and SAR_w on crop yield were:

Yield decrement % $= -28.708 + 14.884\ EC_w + 1.608\ SAR_w$

$= -25.541 + 17.016 EC_w + 1.098\ SAR_w$

$= -16.089 + 14.867\ EC_w + 0.784\ SAR_w$

$= -21.116 + 6.135 EC_w + 1.286\ SAR_w$

$= -22.323 + 4.902 EC_w + 1.0\ SAR_w$

For soybean, sunflower, canola, cotton and sugarbeet crops, respectively

Key words: Guideline, Irrigation water, Salinity, Sodicity

INTRODUCTION

Field crops are differ greatly in their response to salinity according to species, variety, physiological stage of plant growth and environmental conditions (*Balba, 1992, FAO, 1976 and Mefferies, 1988*).

Mass, (1986), tabulated a number of economic crops according to their tolerance to salt and stated that, cotton and sugarbeet are tolerant crops while soybean is moderately tolerant and sunflower is moderately sensitive crop.

The salt tolerance of various crops are conventionally expressed (after Mass and Hoffman, 1977), in terms of relative yield, threshold salinity value (a) and percentage decrement value per ECw unit over the threshold (b), while soil salinity is expressed in terms of ECe, in dSm^{-1}, as the follows:

$Y = 100 - b\ (ECe - a)$

The use of saline water for irrigation should be evaluated for the specific conditions where it is used, since the crop yields depend on leaching fraction and climatic factors at the same locality. It was also found that, the model recommended for the relation between yield and soil salinity by Mass, dose not fit well for yield and irrigation water salinity Adb *El-Gawad and Ghaibeh, (1998)*. Systematic approach was suggested by *Abd El-Gawad and Ghaibeh, (1997)*, to determine the relative yield as result of increasing salinity of irrigation water. Therefore they considered the EC in equation of Mass represents the mean electrical conductivity of the irrigation water throughout the season, and they suggested quadratic and exponential equations as follows:

$Y = A + B\,(EC - T) + C\,(EC - T)^2$ and

$Y = A\ \exp.\ (EC - T)$

Where A is the absolute yield, B is the slope, EC is the mean value of electrical conductivity of the irrigation water throughout the season, and T salinity threshold expressed in dSm^{-1}.

The effect of salinity and sodicity on plant growth is related to high osmotic pressure of soil solution which results in decreasing the physiological availability of water, and accumulation of toxic ions within the plant tissues, (Tavassoli, *1980*). In this respect, *El-Shakweer and Barkat, (1984)* stated that, seed cotton yield was reduced to 60% by raising of salinity of irrigation water from 200 to 8000 ppm and to 80% by raising of Adj. SAR from 10 to 30. Also, they added that the reduction of seed cotton yield due to salinity was increased as Adj. SAR increased.

On the other hand, *DRI (1993)* reported that, the drop in the cotton yield amounts to 25 % with irrigation water salinity up to 6000 ppm.

Abd El-Gawad and Ghaiba, (1998), stated that, the reduction of cotton yield were 11, 9.8 and 9.1 % when the EC of irrigation water increased one unit at zero, 0.15 and 0.30 leaching fraction, respectively. They added that, the ECw of zero yield were 13.8, 15.0 and 15.7 dSm^{-1} at the previous levels of leaching fraction.

Concerning soybean yield, *DRI, (1993)*, stated that, the yield of soybean was highly related to the irrigation water salinity where the yield was reduced by 12, 37 and 74% at salt concentration of 1500, 2400 and 3100 ppm, respectively. The sugarbeet yield decrement amount to 25% with EC of irrigation water 7.5 dS/m and soil salinity 11 dS/m while the same reduction in soybean yield was detected with ECw 4.02 dS/m and the ECe 6.2 *(FAO, 1976)*.

Mass, (1986) stated that, cotton and sugarbeet are tolerant crops while sunflower is moderately sensitive to salinity. He also stated that the soybean is moderately tolerant crop, and its yield was reduced by 16% with increasing one unit of ECw.

The objectives of this study are to evaluate the usability of low quality water with different levels of ECw and SARw for irrigating five crops and to introduce a primary guideline of salt tolerance for these crops under local conditions.

MATERIALS AND METHODS

Long term experiment was conducted in lysimeters using sand culture technique at Sakha Agricultural Research Station in five successive growing seasons started in summer season 1999, to study the effect of salinity and sodicity of irrigation water on the yield of soybean, canola, sunflower, sugarbeet and cotton crops. The experiment was conducted in split-plot design with three replicates. Three levels of sodium adsorption ratio, SAR (10, 15 and 20) were assigned in the main plots, while the salinity levels occupied the sub-plots. The levels of salinity as electrical conductivity EC, were 1, 2, 4, and 8 dSm^{-1} for soybean, sunflower and canola crops, and were 2, 4,6,and 8 dSm^{-1} for cotton and 4, 8, 12 and 16 dSm^{-1} for sugarbeet crop. The control plots were irrigated with fresh water(EC= 0.5 dSm^{-1}). Hogland's nutrient solution was used with all treatments to supply the crops with essential macro and microelements.

Artificial salty solutions with different levels of EC and SAR were prepared using NaCl and CaCl salts. After germination, the plants were thinned to fixed uniform and well-distributed plants per plot.

Fresh water was used for irrigation till complete germination, then the plant were watered with Hoagland solution containing salt mixture in different concentrations. In order to avoid salt shocking the young seedling, the solutions were applied stepwise to the cultures to reach the finally required concentration. To obtain fixed osmotic pressure and to avoid moisture stress, water losses by evapotranspiration was daily compensated.

RESULTS AND DISCUSSION

1. ***Effect of Salinity and Sodicity of Irrigation Water on Yield***

The yield or the economic value of the crop is taken as a criterion when cultivated plants are compared together according to their tolerant to salt. Usually the relative yield of the crops irrigated with saline water is compared with its absolute yield with fresh water. The salt level of soil causing a 50% or 25 % yield depression are taken as the tolerable soil salt level for the given crop, (FAO, 1973).

Data of absolute and relative yield of sugarbeet, soybean, sunflower, canola and cotton as influenced by different levels of

salinity and sodicity of irrigation water are listed in Table (1). As a general trend, the yields of different crops decreased as salinity and sodicity levels in irrigation water increased. The relatively decrement in the yields were differed from crop to another on based of their tolerant to salinity and sodicity.

Cotton and sugarbeet are tolerant crops, while sunflower and canola are moderately sensitive while soybeann is moderately tolerant crops. These results are in good agreement with those obtained by FAO, (1976) Mass, (!986) DRI, (1993) and Rhodes et al (1992).

2. ***Mathematical Relations between Relative Decrement of Different Crop Yield and Salinity of Irrigation Water under Different SAR Levels.***

Data of relative decrement of yield versus salinity and sodicity of irrigation water were evaluated throughout linear equation for each crop.

The relative yield decrement % represent the dependant variable while the salinity expressed in EC dSm-1 represent the independent variable and the equation takes the form Y = ax + b

Where: y: Relative decrement %. X: Salinity of irrigation water

a: Slope (yield reduction % with increasing ECw by one unit)

b: The intercept.

Different liner equations for every crop and representative graphics described these equations were presented in Fig (1). Linear equations and representative graphics of different crops indicate that, the relative yield decrements % with increasing one unit of ECw were 16.02, 14.59, 13.88, 6.44 and 5.37% for sunflower, canola, soybean, cotton and sugarbeet crops, respectively. Also, it could be observe that, with increasing SAR, the crop reduction % increase with increasing ECw. Also, it could be concluded that, the crops under consideration can be arranged in the following descending order, from salt tolerant of view.

Sugarbeet < Cotton < soybean < Canola < Sunflower

Table (1): Yield of different crops and relative decrements % as affected by salinity and sodicity of irrigation water.

Sugar beet (kg/plot)						
EC_w(dS/m)	**Yield**			**Relative Decrement %**		
	SAR 10	**SAR 15**	**SAR 20**	**SAR 10**	**SAR 15**	**SAR 20**
4	3.23	2.95	2.7	6.38	14.49	21.74
8	2.75	2.53	2.25	20.29	26.67	34.78
12	1.88	1.65	1.42	45.51	52.17	58.84
16	1.05	1.0	0.85	69.57	71.01	75.36
Fresh water	3.45			0		
Soybean (g/plot)						
	SAR 10	**SAR 15**	**SAR 20**	**SAR 10**	**SAR 15**	**SAR 20**
1	105	100	95	7.08	11.5	15.93
2	90	88	85	20.35	22.12	24.78
4	58	53	35	48.67	53.1	69.03
Fresh water	113			0		
Sunflower (g/plot)						
	SAR 10	**SAR 15**	**SAR 20**	**SAR 10**	**SAR 15**	**SAR 20**
1	138	132	118.2	3.16	7.37	17.05
2	110.3	105.2	100	22.6	26.18	29.82
4	86.2	75.1	68.2	39.51	47.3	52.14
8	29.2	13.9	13.1	78.84	89.47	88.92
Fresh water	142.5			0		
Canola (g/plot)						
	SAR 10	**SAR 15**	**SAR 20**	**SAR 10**	**SAR 15**	**SAR 20**
1	290	280	260	3.33	6.67	13.33
2	210	200	180	30	33.33	40
4	150	140	130	50	53.33	56.67
8	100	90	70	65.52	67.86	73.08
Fresh water	300			0		
Cotton						
	SAR 10	**SAR 15**	**SAR 20**	**SAR 10**	**SAR 15**	**SAR 20**
2	72.6	65.22	60.17	2.05	12.10	18.82
4	64.28	58.18	53.33	13.28	21.51	28.05
6	53.12	47.83	42.18	28.33	35.47	43.09
8	44.5	39.13	34.12	39.96	47.21	53.97
Fresh water	74.12			0		

3. Preliminary Guideline for Effect of Salinity and Sodicity of Irrigation Water on Some Field Crops at The North Delta.

Data illustrated in Table (3) represent a guideline introduced from previous linear equations of crops. The table includes the expected yield reduction of 10, 25, 50, 75, 90 and 100% due to

increasing irrigation water salinity under three levels of SAR. Data indicate that each increase in irrigation water salinity will cause a proportionate decrease in the yield. Data also indicated that, sugarbeet crop is the most tolerant crop followed by cotton, while sunflower is the least one. On the basis of, 50% reduction in crop yield, the crop can be arranged in the descending order from salt tolerant point of view, sugarbeet > Cotton > soybean > Canola > Sunflower. Data also indicate that the bad effect of SAR on the yields was increased with increasing of ECw of irrigation water and vice versa.

Comparing data presented in preliminary Guideline Table (3) with Guideline introduced by FAO,(1976) for cotton, sugarbeet and soybean crops, (Table 2). It could be concluded that, Values of ECw causing 50% reduction of yield were 9.39, 12.71 and 4.1 dSm^{-1} in the current Guideline while the corresponding values of FAO were 12. , 10.0 and 5.0 dSm^{-1} for cotton, sugarbeet and soybean crops, respectively.

Zero yields were detected at 17.28, 22.0 and 7.7 dSm^{-1} while the values of FAO were 18.0, 16.0 and 6.7 dSm^{-1} for the previous crops.

The differences of values between the current Guideline and FAO Guideline may be due to the soil salinity effect, which was taken into consideration by FAO, while the effect on crop yield was related to salinity of irrigation water only in the current Guideline.

Table (2): Yield decrement to be expected for some crops as results of soil and irrigation water salinity (FAO, 1976).

Crops	Yield decrement									
	Zero		10%		25%		50%		100%	
	ECw	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	ECe
Cotton	5.1	7.7	6.4	9.6	8.4	13.0	12.0	17.0	18.0	27.0
Sugarbeet	4.7	7.0	5.8	8.7	7.5	11.0	10.0	15.0	16.0	24.0
Soybean	3.3	5.0	3.7	5.5	4.2	6.2	5.0	7.5	6.7	10.0

Table (3): Yield Decrement to be expected for Certain Crops due to Salinity and sodicity of irrigation water.

						SAR 10
			EC_w			
Crops	10 %	25 %	50 %	75 %	90 %	100%
Soybean	1.225	2.305	4.106	5.907	6.988	7.708
Sunflower	1.325	2.262	3.822	5.382	6.318	6.943
Canola	1.145	2.173	3.887	5.601	6.629	7.315
Sugarbeet	5.26	8.06	12.71	17.37	20.02	22.024
Cotton	3.46	5.68	9.39	13.09	15.32	16.8

						SAR 15
			EC_w			
Crops	10 %	25 %	50 %	75 %	90 %	100%
Soybean	1.079	2.101	3.804	5.506	6.528	7.209
Sunflower	1.166	1.997	3.384	4.77	5.602	6.157
Canola	1.004	2.013	3.695	5.377	6.386	7.058
Sugarbeet	3.63	6.70	11.83	16.95	20.03	22.08
Cotton	3.61	6.07	10.16	14.26	16.71	18.35

						SAR 20
			EC_w			
Crops	10 %	25 %	50 %	75 %	90 %	100%
Soybean	0.953	1.746	3.069	4.392	5.185	5.714
Sunflower	.909	1.774	3.216	4.658	5.524	6.101
Canola	0.747	1.735	3.382	5.029	6.017	6.676
Sugarbeet	1.85	5.09	10.50	15.91	19.15	21.317
Cotton	3.37	5.82	9.92	14.01	16.47	18.11

4. ***The Combined Effect of ECw and SARw:***

The combined effect of salinity and sodicity of irrigation water on the relative yield decrement of every crop is described through the multiple regression equations according to Pindyck and Rubinfeld, (1976) as follows:

4.1 Soybean crop

Yield decrement % = -28.708 + 14.884 ECw + 1.608 SAR. (R^2= 97.1%)

4.2 Sunflower crop:

Y = -25.541 + 17.016 ECw + 1.098 SAR (R^2= 99.6%)

4.3 Canola crop:

Y= -16.089 + 14.867 Ecw + 0.784 SAR (R^2 = 100.%)

4.4 Cotton crop

Y= -21.116 + 6.135 Ecw+1.286 SAR (R^2=99.9)

4.5 Sugarbeet

Y = -22.323 + 4.902ECw + 1.0 SAR (R^2= 99.6 %)

Table (4) The combin effect of Ecw and SARw on relative yield decrement (%):

Cotton crop:

SAR	ECw(dS/m)												
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	12.00	14.00	16	18
5.00	0.00	0.00	3.72	9.85	15.99	22.12	28.26	34.39	46.66	58.93	71.20	83.47	95.74
10	0.00	4.01	10.15	16.28	22.42	28.55	34.69	40.82	53.09	65.36	77.63	89.90	*
15	4.31	10.44	16.58	22.71	28.85	34.98	41.12	47.25	59.52	71.79	84.06	96.33	*
20	10.74	16.87	23.01	29.14	35.28	41.41	47.55	53.68	65.95	78.22	90.49	*	*
25	17.17	23.30	29.44	35.57	41.71	47.84	53.98	60.11	72.38	84.65	96.92	*	*
30	23.60	29.73	35.87	42.00	48.14	54.27	60.41	66.54	78.81	91.08	*	*	*

Soybean crop:

SAR	ECw(dS/m)												
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	12.00	14.00	16	18
5.00	0.00	9.10	23.98	38.87	53.75	68.64	83.52	98.40	*	*	*	*	*
10	8.26	23.14	38.02	52.91	67.79	82.68	97.56	*	*	*	*	*	*
15	10.33	25.21	40.09	54.98	69.86	84.75	99.63	*	*	*	*	*	*
20	11.43	26.32	41.20	56.08	70.97	85.85	*	*	*	*	*	*	*
25	26.38	41.26	56.14	71.03	85.91	*	*	*	*	*	*	*	*
30	34.42	49.30	64.18	79.07	93.95	*	*	*	*	*	*	*	*

Sunflower crop:

SAR	ECw(dS/m)												
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	12.00	14.00	16	18
5.00	0.00	13.52	30.54	47.55	64.57	81.59	98.60	*	*	*	*	*	*
10	2.46	19.47	36.49	53.50	70.52	87.54	*	*	*	*	*	*	*
15	7.95	24.96	41.98	58.99	76.01	93.03	*	*	*	*	*	*	*
20	13.44	30.45	47.47	64.48	81.50	98.52	*	*	*	*	*	*	*
25	18.93	35.94	52.96	69.97	86.99	*	*	*	*	*	*	*	*
30	24.42	41.43	58.45	75.46	92.48	*		*	*	*	*	*	*

Canola crop:

SAR	ECw(dS/m)												
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	12.00	14.00	16	18
5.00	2.70	17.57	32.43	47.30	62.17	77.03	91.90	*	*	*	*	*	*
10	6.62	21.49	36.35	51.22	66.09	80.95	95.82	*	*	*	*	*	*
15	10.54	25.41	40.27	55.14	70.01	84.87	99.74	*	*	*	*	*	*
20	14.46	29.33	44.19	59.06	73.93	88.79	*	*	*	*	*	*	*
25	18.38	33.25	48.11	62.98	77.85	92.71	*	*	*	*	*	*	*
30	22.30	37.17	52.03	66.90	81.77	96.63	*	*	*	*	*	*	*

5)Sugarbeet crop:

SAR	ECw(dS/m)														
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	12.00	14.00	16	18	20	22
5.00	0.00	0.00	0.00	2.29	7.19	12.09	16.99	21.89	31.70	41.50	51.31	61.11	70.91	80.72	90.52
10	0.00	0.00	2.38	7.29	12.19	17.09	21.99	26.89	36.70	46.50	56.31	66.11	75.91	85.72	95.52
15	0.00	2.48	7.38	12.29	17.19	22.09	26.99	31.89	41.70	51.50	61.31	71.11	80.91	90.72	*
20	2.58	7.48	12.38	17.29	22.19	27.09	31.99	36.89	46.70	56.50	66.31	76.11	85.91	95.72	*
25	7.58	12.48	17.38	22.29	27.19	32.09	36.99	41.89	51.70	61.50	71.31	81.11	90.91	*	*
30	12.58	17.48	22.38	27.29	32.19	37.09	41.99	46.89	56.70	66.50	76.31	86.11	95.91	*	*

* Yield decrement more than 100%

Using multiple regression equations, yield decrement % of different crops as affected by wide levels of both EC_w and SAR_w were calculated and presented in Table (4).

Data confirm the previous data where the sugarbeet and cotton were more salt tolerant crops followed by soybean, canola and sunflower.

Data also revealed that, sugarbeet crop seem to be tolerance to increase of sodium concentration where it recorded the least yield decrement with increasing SAR at a given ECw.

Crops under consideration could be arranged in the following descending order according to their resistance of sodium concentration.

Sugarbeet >cotton>canola>sunflower>soybean.

5. *crop yield decrement according to ECw and SARw classes suggested by Richard (1954).*

Multiple regression equation for every crop was used to evaluate the different classes suggested by Richard (1954) for evaluating water quality and its suitability for irrigation under North Delta conditions. Data for every crop under different classes in sandy soil were calculated and presented in Table (5).

Table (5): Crop yields decrement (%) according to Richard's classes under North Delta conditions.

Class	Sunflower	Soybean	Canola	Cotton	Sugarbeet
C_1-S_1	0	0	0	0	0
C_2-S_1	0	0	0-2.9	0	0
C_3-S_1	0 - 23.7	0 - 20.9	2.9 - 25.2	0 - 5.6	0
C_4-S_1	> 23.7 **	> 20.9 **	> 25.2 **	> 5.6 **	**
C_1-S_2	0	<4.0	<1.7	<3.6	0
C_2-S_2	0-7	4.0 - 11.4	1.7 - 9.2	3.6 - 6.6	0
C_3-S_2	7.0 - 32.5	11.4 - 33.7	9.2 - 25.2	6.6 -15.8	0 - 6.7
C_4-S_2	>32.5**	>33.7**	>25.2**	>15.8**	>6.7**
C_1-S_3	<7.3	<16.8	<8.0	<13.8	<4.9
C_2-S_3	7.3 - 15.8	16.8 - 24.3	8.0 -15.5	13.8 - 16.9	4.9 - 7.4
C_3-S_3	15.8 - 41.3	24.3 - 46.6	15.5 - 37.8	16.9 -26.12	7.4 - 14.7
C_4-S_3	>41.3**	>46.6**	>37.8**	>26.12**	>14.7**
C_1-S_4	*	*	*	*	*
C_2-S_4	*	*	*	*	*
C_3-S_4	*	*	*	*	*
C_4-S_4	***	***	***	***	***

* The decrement is accurately defined according to S_4 values.

** The decrement is accurately defined according to C_4 values

*** The decrement is accurately defined according to both C_4 and S_4 values.

The data in Table (5) evidently proved that all water salinity and sodicity levels used under sandy culture are suitable for sugarbeet crop if 15% yield is supposed to be an acceptable decrement level.

Cotton crop seems to be tolerant to salinity but less tolerant to sodicity than sugarbeet. So, all salinity levels with low sodicity (S1) are suitable for cotton according to this proposition.

Soybean is the least tolerant to salinity comparing to other crops under this evaluation. So, it tolerates low salinity level ($C_1$and C_2) combined with lower sodicity levels ($S_1$and S_2) with yield decrement less than 15% .

Canola and sunflower are slightly more tolerant to sodicity than soybean, since they tolerate (C_1 and C_3) class , in addition to the salinity classes tolerated by soybean .

According classes of Richard (1954) the tolerance to salinity and sodicity of the studied crops can be arranged as the following descending order:

Sugarbeet>cotton >canola = sunflower >soybean

CONCLUSION

It can be concluded that, to introduce an integrated guideline, further trials on different soil types, field crops, at various locations, using different irrigation systems, under various leaching fractions are needed.

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الملخص العربي

دليل أولى لاستجابة المحاصيل لملوحة و قلوية ماء الري تحت ظروف منطقة شمال الدلتا

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معهد بحوث الأراضي و المياه و البيئة – مركز البحوث الزراعية

تم إعداد دليل أولى لمقاومة محاصيل فول الصويا ، الكانولا ، عبـاد الشـمس ، القطـن وبنجر السكر لملوحة و صودية مياه الري تحت الظروف المناخيـة لمنطقـة شـمال الـدلتا باستخدام أسلوب المزارع الرملية.تم استنتاج المعادلات الخطية التي توضح العلاقة بين نقـص محاصيل عباد الشمس و الكانولا ، فول الصويا ، القطن ، بنجر السكر عنـد زيـادة ملوحـة وقلوية ماء الري .

أوضحت النتائج أن زيادة قلوية ماء الري تزيد من تأثير ملوحة ماء الري . على المحصـول . ومن خلال النتتائج أمكن ترتيب المحاصيل علي حسب مقاومتها لملوحة وصودية ماء الري في الترتيب التنازلي التالي:

بنجر السكر > القطن > فول الصويا > الكانولا > عباد الشمس .

Hydrochemical Study of Groundwater in El Dakhla Oasis

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ABSTRACT

The present study revealed that the Nubian Sandstone basin in the study area is a part of huge groundwater reservoir extending to cover Wadi El Gedid area and El-Uwienat. The hydrogeology of the study area where the aquifer system in Nubian Sandstone basin is divided into various groundwater basins hydraulically connected in various degrees to the major Nubian basins in the countries sharing the regional aquifer. The movement of groundwater in Nubian Sandstone aquifer is from southwest to northeast. All groundwater samples were chemically and microbiologically analyzed showing their contents and possibility of contamination with major elements, trace elements and microbiology. These analyses showed that, all the concentration of the elements is less than the permissible limits, according to World Health Organization (1984) that can be used in all purposes. Trace elements were analysed in the groundwater samples. The results of analysis are less than the recommended limits except the concentrations of iron and manganese which were more than the permissible limit according to WHO guideline. This water is unsuitable for drinking. The water must be treated before being used in drinking to remove the iron and manganese contents to reach the standard limit for drinking. The Nutrients contents range is less than the standard limit and the groundwater can be used in different purposes without any harmful effects. From the results of microbiologic analysis, there is no pollution by bacteria.

1-INTRODUCTION

Water is the most abundant liquid on Earth. Nile water is considered the main renewable source of fresh water in Egypt. Groundwater and rainfall have a limited potential and constitute the second source. Egypt has fixed share of the Nile water amount to 55.5 billion m^3/year. Since the Agreement of 1959 with the Sudan, more than 85% of Egypt's water resources are utilized for agriculture. Population increase during the past three decades increased water demand and the conjunctive use of the groundwater together with surface water became a very essential policy to satisfy the ever-increasing water demands.

The increasing population, together with agricultural expansion and industrial activities resulted in pollution of groundwater. Therefore, it is necessary to evaluate the existing groundwater conditions and quality and its suitability for the different uses in the Dakhla Oasis.

The Nubian Sandstone basin occupies an area of more than 2.5 million km^2 and underlies the common border area between Egypt, Sudan, Libya and Chad. In Egypt the Nubian Sandstone occupies the western desert composed of El Wadi El Guedid depression with an area of 600,000 km^2 including the large oases of El Kharga, El Dakhla, Farafra and Bahariya.

El Dakhla Oasis constitutes one of the main five Oases distributed over the Western Desert of Egypt. It is relatively a narrow depression lying between

Farafra and El Kharga Oases to the northwest and southeast, respectively. The depression extends for about 55 Km from east to west and about 25 km from north to south and occupies and area between latitude $25^0 15^-$ - 26^0 North and longitudes $20^0 15^-$ - 29^0 30^- East, as shown in Figure (1).

The geology, hydrogeology and hydrochemistry of groundwater in the studied area have been previously discussed by Youssef (1957), El Kiki and Hassan (1973 & 1974) and Atta (1989).

2- MATERIAL AND METHODS

Forty one groundwater samples were collected from wells of different depths covering all area as shown in Figure (1). Samples were analysed for their cations and anions applying the American Public Health Association (1995). Also, trace elements, Nutrients and Microbiology were analysed by American Public Health Association (1995).

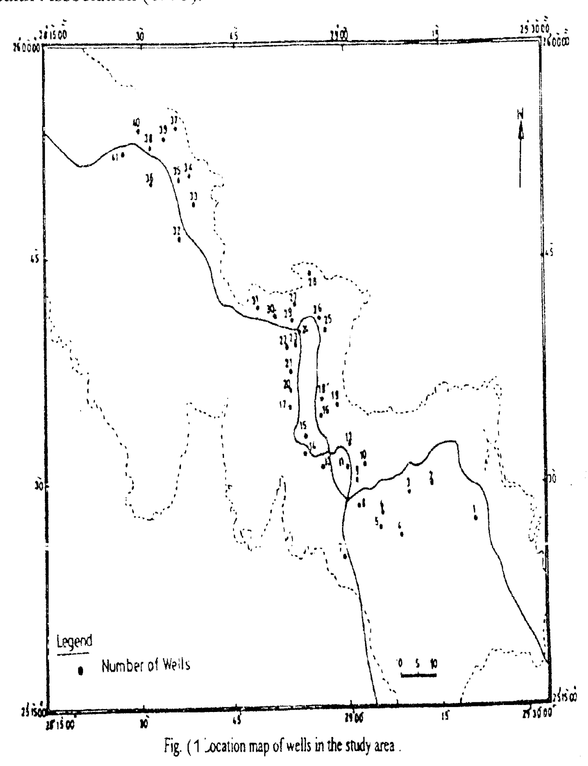


Fig. (1 Location map of wells in the study area .

3- RESULTS AND DISCUSSION

3.1 Chemical composition

pH value: The pH of the natural water ranges between 6.0 and 8.5. The results of the water samples of the studied area indicated that the pH values ranged between 7 - 7.6. The minimum value was found in well No. 27, while the maximum value was found in well No. 2 in the east.

Salinity content: The salinity is mainly governed by the geographical position of each locality. The results indicate that TDS ranged between 152 to 357 ppm. The minimum value was found in well No. 17, while the maximum value was in well No.9. The salinity level is considered medium according to Richard (1954).

Major cations: Potassium content in the groundwater of the studied area is very low as related to its salinity. The content of potassium ranges between 5-18 ppm. The minimum content was found in well No. 38 while the maximum value was found in wells No. 6 & 8. Sodium is directly related to salinity of the groundwater. It varies according to the geographical position of the wells from 11 to 46 ppm. The maximum value was found in well No. 16, while the minimum was found in well No. 14. Magnesium ion in the groundwater of the studied area varies according to the geographical position of the wells from 8 ppm in wells No. 1, 4 & 8 to 28 ppm in well No. 9. Calcium is found in all wells ranges between 8 to 30 ppm. The maximum value was found in well No. 9, while the minimum value was found in wells No. 1, 4, 6, 11, 14, 17, 24 & 28.

Major anions: The range of chloride in the studied area was found between 18 - 53 ppm. The lowest value was found in wells No. 10, 14, 20, 28, 29, 30, 32 & 33, while the maximum value was found in well No. 39. Sulphate in the studied area ranged between18 - 120 ppm. The lowest value was found in well No. 6, while the maximum value was found in well No.16. The values of sulphate ions in the most wells are of high concentration. This is due to the presence of pyrite mineral as ferrous sulphide (Fe S) which dissolves in water and gives sulphate ions and Fe^{+3}. Bicarbonate ions in the study area ranges between 37 - 104 ppm. The minimum value was recorded in well No. 34, and the maximum value was recorded in wells No. 2 & 9. Carbonate ion is not present because the pH values of well samples were between 7.0 - 7.6.

3-2 Nutrients

Nitrates (NO_3): The concentration of nitrate in the groundwater is considered low and ranges from 1.45 ppm in well No. 9 to 1.75 ppm in wells No. 32 & 33.

Phosphate (PO_4): Phosphate content in the groundwater of the study area ranges between 1.4 ppm in wells No. 6, 8, 9, 13, 14, 20, 22, 25, 28, 29, 30 & 41 and 1.95 ppm in well No. 16. The phosphate content in the groundwater of the study area is high and the water is unsuitable for drinking

Ammonia (NH_4): The ammonia content in the studied water samples varies from 0.04 to 0.65 ppm. The concentration is similar in all wells. This phenomena shows that there is no pollution sources in the study area.

3-3 Trace elements

Trace elements were determined in the groundwater samples in the study area to evaluate the water quality. The results of the determination of trace elements in the groundwater samples from 41 wells are given in (Table 1). These elements will be discussed in the following.

Iron (Fe^{2+}): The concentration of iron ranges between (0.5 – 11 mg/l). The minimum value was found in well No. 19 and maximum value in well No. 23. The concentration of iron in the study area is relatively high .

Manganese (Mn^{2+}): The concentration of manganese in water is less than that of iron. A mean expected value is around 0.06 mg/l. When concentration higher than 1 mg/l is found, the manganese bearing minerals are contacted by water under reduced conditions or where bacteria are active.

In the study area ground water samples, manganese content varies from 0.1 - 0.3 mg/l. The maximum value was 0.3 mg/l in wells No. 10 & 28, while the minimum value was found in most wells.

Cadmium (Cd^{2+}): The concentration of cadmium in the groundwater samples of the study area reaches 0.0045 mg/l, which is considered within the permissible limit for drinking and irrigation purposes.

Zinc (Zn 2+): Zinc content was less than 0.2 ppm in all samples. According to WHO (1985) the guideline value for zinc in drinking water is 5 ppm. Therefore, groundwater in the study area is suitable for irrigation

Copper (Cu 2+): Copper content in the groundwater samples of the study area reached 0.1 ppm in all wells. According to FAO (1985), the guideline value of copper in irrigation water is 0.2 mg/l for all soils. Therefore, groundwater in the study area is suitable for irrigation since copper concentration is within the permissible limits.

Lead (Pb^{2+}): Lead content in the groundwater samples is 0.005 ppm. According to FAO (1985), the maximum recommended concentration of lead in irrigation water is 0.009 ppm

Nickel (Ni^{2+}): Nickel content in the groundwater samples of the study area was 0.017 mg/l in all samples. For irrigation water, the recommended maximum concentration of nickel is 0.2 ppm according to FAO (1985). Therefore, the nickel content in the groundwater of the study area is suitable for irrigation.

Boron (B^{+}): Boron content in the groundwater of the study area is 0.1 ppm in all water samples. Therefore, groundwater is suitable for most crops without any problems.

Table (1). Trace Elements Analysis in the Study Area (in mg/l).

Well No.	The depth (m)	Fe	Mn	Cd	Zn	Cu	Pb	Ni	B
1	754	6.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
2	1087	4.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
3	1206	4.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
4	751	5.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
5	436	9.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
6	1020	5.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
7	496	6.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
8	1008	7.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
9	860	6.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
10	770	5.5	0.3	0.0045	0.2	0.1	0.005	0.17	0.1
11	886	0.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
12	255	4.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
13	700	7.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
14	766	5.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
15	257	7.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
16	288	6.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
17	800	8.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
18	451	3.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
19	498	0.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
20	800	6.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
21	1000	6.5	0.2	0.0045	0.2	0.1	0.005	0.17	0.1
22	902	7.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
23	485	11.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
24	354	3.5	0.2	0.0045	0.2	0.1	0.005	0.17	0.1
25	709	5.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
26	485	9.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
27	494	6.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
28	815	6.0	0.3	0.0045	0.2	0.1	0.005	0.17	0.1
29	800	3.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
30	1010	4.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
31	705	5.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
32	455	6.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
33	498	3.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
34	635	4.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
35	546	3.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
36	500	5.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
37	547	3.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
38	807	3.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
39	588	4.5	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
40	551	5.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1
41	805	5.0	0.1	0.0045	0.2	0.1	0.005	0.17	0.1

3-4 Microbiological Characteristics

Total coliform and faecal coliform counts were preformed . The analyses showed that all water samples were not polluted with total and faecal coliform due to the great depth of the wells that vary between 255 m to 1206 m. Most of the microorganism and bacteria do not live in these depths.

3-5 Hydrochemical Composition of the Study Area

Genetic classification of groundwater by Sulin' s Graph

Sulin's Graph (1948) for genetic classification of groundwater is used to indicate the water genesis and water type from the hydrochemical composition. By applying Sulin's Graph (Figure 2) on the present groundwater samples, the water origin could be determined for the different localities. The hydrogeochemical composition of the groundwater of the study area reflects the meteoric of such water where the equivalent concentration of both potassium and sodium is greater than chloride (r(K+Na)/rCl) > 1.

The representation of the hydrochemical composition of Sulin's Graph (Figure 2) shows that the groundwater belongs to Na_2SO_4 type. An excess of sodium ions combined with sulphate ions. This indicates that, the groundwater in the Dakhla Oasis is considered old meteoric water.

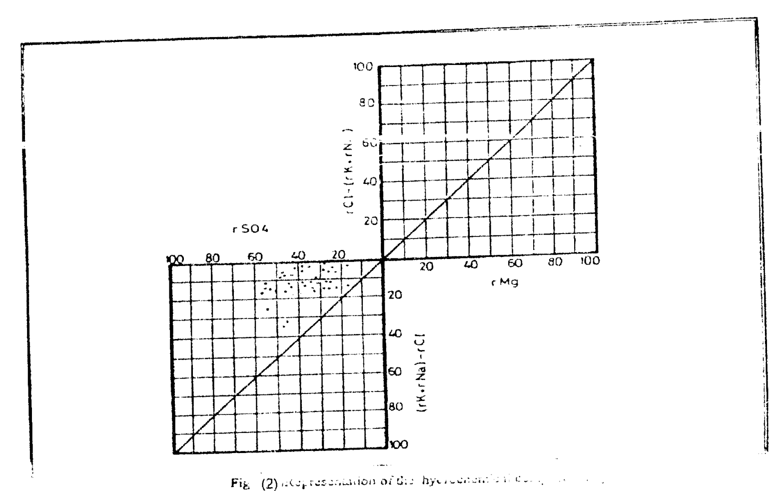


Fig (2) Representation of the hydrochemical composition ... Sulin's graph in the study area.

3-6 Cluster Analysis

Cluster analysis is an old classification technique dating back to 1930 and designed to select subsets of mutually similar elements from a matrix of many variable and/or cases. The cluster analysis was carried out in order to identify groups of wells, which represent homogenous water bodies as well as to identify interconnection such as mixing and dilution (Harbaugh and Merriam, 1968).

The simple form of cluster analysis is to define a simple form of correlation analysis developed from the raw data matrix and defines pair by pair, the inter-correlation of variables (R-mode) or cases (Q-mode) in a two dimensional, hierarchical diagram called the (Dendogram). In such a cluster, diagram of each variable or case has a unique position in order to easily simplify the interpretation of the cluster results.

This is the other most commonly used method in geology because of the results being reasonably significant since the method considers a cluster group illustration as a whole. (Figure 3) represents this set of analysis in the dendrogram illustration.

Q- mode:

Q-Mode means the cases (wells), which the cluster is used to produce the Dendogram. From the appearance, there are some levels of correlation among the cases (wells) but one level (A-A\) can be distinguished with Edulidean distance (1 cm-35.7 of Euclidean distance) and the range is 500 at the level (A- A\). At similarity level A- A\, there are three main clusters described as follows:

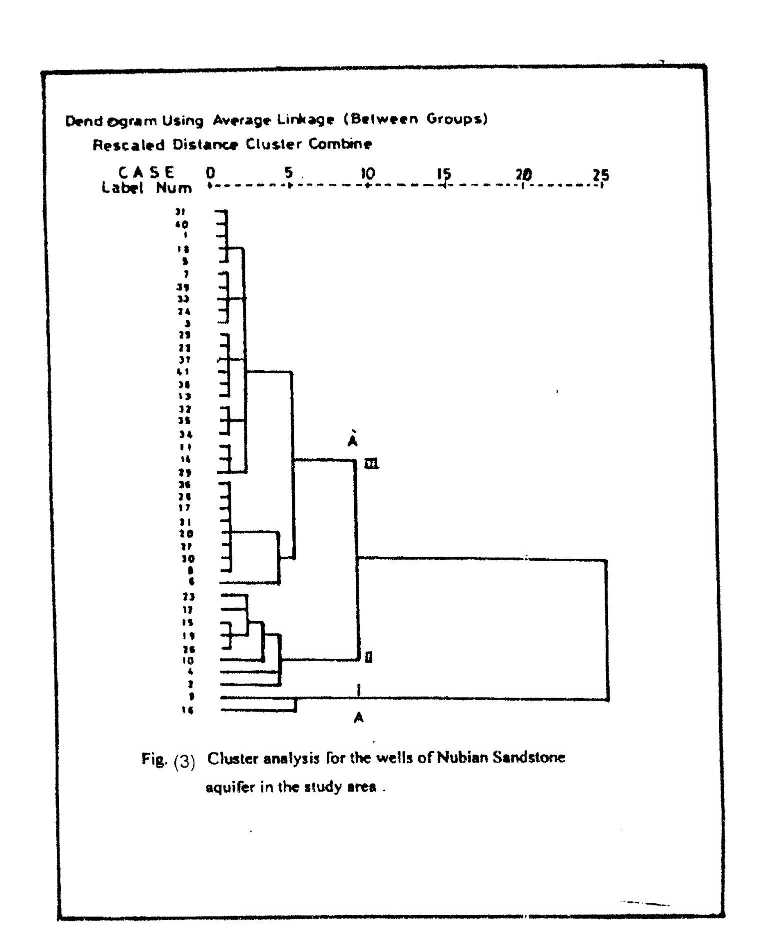


Fig. (3) Cluster analysis for the wells of Nubian Sandstone aquifer in the study area .

Cluster I: Formed cases No. 16 & 9, which represent the wells No. 16 & 9 are characterized by high salinity ranging from 311 to 357 ppm. This is due to many reasons, among which flow direction. Another reason is the topography of Dakhla area. It is a depression where the recharge of aquifer is from two directions. The same cluster is characterized by high sulphate, which was increased due to the lithologic formation of zones, formed the aquifer.

Cluster II: Formed cases No. 2, 4, 10, 26, 19, 15, 12 & 23, show low salinity which ranges between 230 ppm to 297 ppm and low sulphate content characterizes these wells.

Cluster III: Formed 31 cases are the other wells inside the study area, which are characterized by very low salinity and low content of cations and anions. The salinity in this cluster ranges between 150 ppm to 225 ppm. The similarity of most clusters is due to the same water origin where it is meteoric water. From the above interpretation the cluster analysis can define and isolate the similar wells better than the other diagram. Sulin's Graph shows the aerial distribution of three clusters of the Nubian Sandstone aquifer in the study area.

3-7 Correlation Coefficient Calculated for Different Samples from the Aquifer:

The statistical analysis was conducted among the different chemical parameters. The results of the correlation coefficient as shown in (Table 2) indicate the following: the correlation coefficient between the TDS and the other ions indicate high values between the TDS and Mg, Na, Ca, SO_4, The values were higher than 0.5 . These results are expected because these ions in addition to Cl are the main components of the soluble salts.

4- CONCLUSIONS AND RECOMMENDATIONS

From the previous discussion the following can be concluded:

1. There are relatively high increases in iron and manganese content in the groundwater of the studied area over the recommended limits.
2. By applying Sulin's Graph, the groundwater is considered meteoric water
3. Water can be used for drinking after getting rid of iron and manganese.

Table (2). Correlation Coefficient Calculation of Different Samples from the Aquifer:

Variable	TDS	pH	K	Na	Mg	Ca	Cl	SO_4	HCO_3	Fe	Zn	Mn	SiO_2
TDS	1												
pH	0.24	1											
K	-0.13	-0.22	1										
Na	0.64	-0.07	-0.38	1									
Mg	0.78	0.26	-0.01	0.26	1								
Ca	0.52	0.39-	-0.44	0.37	0.22	1							
Cl	0.42	-0.11	-0.46	0.78	0.15	0.34	1						
SO_4	0.8	0.2	-0.05	0.5	0.75	0.42	0.08	1					
HCO_3	0.42	0.2	-0.03	0.19	0.42	0.09	0.12	0.12	1				
Fe	0.12	-0.16	0.1	0.12	0.06	0.17	0.18	0.01	0.19	1			
Mn	0.07	-0.05	0.33	0.05	0.35	0.22	0.26	0.29	0.02	0.02	1		
Zn	0.33	-0.13	0.5	0.16	0.43	0.06	0.06	0.27	0.18	0.19	0.09	1	
SiO_2	-0.07	0.01	-0.22	0.01	0.01	0.1	0.08	0.07	0.17	0.15	0.03	-0.04	1

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الملخص العربي

دراسة هيدروكيميائيه للمياه الجوفية في واحة الداخلة

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*معهد البحوث والدراسات الأفريقية – جامعه القاهرة ** كليه العلوم قسم الجيولوجيا جامعه القاهرة
*** المركز القومي لبحوث المياه القناطر الخيرية

تناول البحث دراسة الخواص الهيدروكيميائية للمياه الجوفية في خزان الحجر الرملي النوبي وبصفة خاصة في واحة الداخلة التي تمثل جزء من حوض الداخلة المكون للخزان الرملي النوبي بغرض تحديد صلاحية المياه الموجودة في الخزان الرملي النوبي للاستخدامات المختلفة من ري وزراعة وشرب وصناعة و كانت النتائج كالآتي: تتراوح الملوحة الكلية في المياه الجوفية في واحة الداخلة من 150–351 جزء في المليون ويمكن أن نستنتج من هذه القيمة أن المياه صالحة للاستخدام في كل الأغراض لأنها تقل عن الحدود المسموح بها. وبالنسبة للعناصر الكبرى تتراوح تركيزات العناصر بأقل من الحدود المسموح بها طبقا للقيم القياسية لمنظمة الصحة العالمية ومنظمة الأغذية والزراعة. يتراوح تركيز العناصر المغذية إلى اقل من الحدود المسموح بها وبالتالي يمكن استخدام المياه في جميع الأغراض المختلفة.أما بالنسبة للعناصر النادرة وهى من أهم العناصر وأكثرها خطورة في تلوث المياه نتيجة لأثارها على الصحة العامة للإنسان وكذلك في النبات وتدهور الأراضي بمرور الوقت ، فقد تم تحليل العناصر النادرة في المياه وذلك لمعرفة مدى أمكانية حدوث تلوث المياه الجوفية بهذه العناصر وقد أظهرت النتائج أن تركيزات العناصر النادرة في الحدود المسموح بها عدا عنصري الحديد المنجنيز ، وكان من نتائج التحليل البكتريولوجى لبكتريا القولون والعدد الكلي للبكتريا أن منطقة الدراسة لا يوجد بها أي تلوث بكتريولوجى

Technical session 4

Soil Erosion and Conservation Methods

- *A.A Ali, S.F.T. Sharkawy and M.M Wassif*
  " Soil Erosion by Rainfall In North Western Coastal Zone, NWCZ, of Egypt ".
  Desert Research Center, Soil Conserv. Dept., Mataria, Cairo, Egypt.
- *S.F.T. Sharkawy, A.A.Ali and M.M. Wassif*
  " Soil Erosion By Wind InNorth Western Coastal Zone, NWCZ, of Egypt"
  Desert Research Center, Soil Conserv. Dept., Mataria, Cairo, Egypt.
- *G.Abdel-Rhman*
  "Agrometeorology and its relation to probability of desertification in El-Bahariya depression, western desert, Egypt"
  (Desert Res. Center, El-Mataria, Cairo)
- *A.A.Sharaky*
  "Sand dunes movement and its effect on agricultural lands, El_Dakhla oasis, Western Desert, Egypt"
  (Dept.of Natural Resources, Inst.of African Res.&Studies, Cairo Univ.)

Soil Erosion by Rainfall
In
North Western Coastal Zone, NWCZ, of Egypt

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ABSTRACT

Two experiments were carried out to evaluate the rate of soil erosion by rainfall in NWCZ of Egypt. The first one was carried out under laboratory rainfall simulator, conditions, Desert Research Center(DRC), to study the impact of some soil properties, slope length and drop size on the quantity of soil loss and runoff volume.

The second one was field experiment which conducted in west Matruh city, NWCZ, Egypt under natural rainfall conditions, to evaluate the rate of soil erosion under three different slop length (10-m, 20-m, and 40-m) at 9% slope from unbounded plots.

The results showed that, the increasing soil moisture content increased the values of soil loss and runoff. The relationship between time before runoff began and runoff or soil loss was calculated.

The data showed that the amount of rainfall through sixteen storm during the study period was 140.6-mm, when the amount of rainfall was less than 10-mm, the runoff was not occurred. Also, the differences in runoff and soil loss were evident between bare soil and planted treatment with barley. Runoff and soil loss for planted treatments decreased by 41.6% and 40.6% , respectively , relative to bare soil treatment. Amount of soil loss and runoff increased with increasing slope length. Also the relationship between soil loss and biological yield of barley was evaluated.

It can be concluded that dividing slope length to 10 m apart could be recommended for controlling water erosion under rainfed agriculture.

INTRODUCTION

Soil erosion process begins when raindrops strike the soil surface. Raindrop energy serves to breakdown aggregates on the soil surface and detach soil particles from the mass.

The NWCZ suffer from water soil erosion hazards because of the relative high rainfall erosivity in certain periods of the year, undulating of pography, the low density of plant cover, low soil depth and lack of soil

structure. It is known that both water erosi)n and runoff are affected by several factors such as climate, soil and land use factor.

Soil moisture is an important factor that affects detachability and accordingly, soil erosion by water. Trunman and Bradford (1990) reported that prewetting of soil reduced splash detachment rates for different types of soils. Prewetting increased soil shear strength for 60 minutes following rainfall. They found that antecedent soil moisture content conditions prior rainfall influenced the amount of splash detachment.

The degree of water erosion is generally directly related to the degree and length of slope. It is also affected by the shape of slope and of watershed. Morgan (1995) found that increased slope steepness associated with ridged plots reduced the degree of surface sealing as indicating by decreased soil strength. Bajracharya and Lal (1992) reported that rate of erosion depends on a complex interrelationship among erosive forces of rainfall and runoff (erosivity) and susceptibility of the soil to detachment by these forces (erodibility). Sala et al. (1997) reported that plant cover play an important role in reducing erosion and protecting soil against degradation. They also found that negative exponential relationship between soil loss and the mean value of vegetal cover. Savabi and Stout. (1994) reported that vegetation removel induces changes in soil quality which affects erosion erosion prevention and restoration of eroded and degraded soil depends on understanding the interaction between soil quality and soil erosion

MATERIALS AND METHODS

This study included laboratory and field experiments. These experiments are:

Laboratory experiments:

Laboratory experiments were conducted using rainfall simulator model FEL3 with spinning disc simulator to study some factors acting on soil erosion. Areas soil samples were Fuka, Wadi eL Ramla; west Matruh, and Sidi Barrany. Disturbed soil samples (0-30cm) were collected ,air dried, crushed to pass a 4 mm sieve layers of the soil material, 10 cm high.

Experiment 1:

Four different soil moisture contents were used as follows:

- Saturation: this was done by filling the tray container with water from the bottom for a few days until it reached the saturation point.

- Field capacity: it was adjusted by spraying the proper amount of water on the tray surface.
- Five bar: the soils were exposed to a pressure of 5 bar moisture content.
- Air dried soils (Control)

Experiment 2:
The aim of this study was to study the effect of some soil properties on the rate of soil loss and runoff under simulated rain at 9% slope.

Experiment 3:
Four trays differ in their length (10,20,30 and 46 cm) were used to study the effect of slope length on the rate of runoff and soil loss, at rainfall intensity 20 mm/hr.

Experiment 4:
Three different drop size of simulated rainfall were used to study the effect of drop sizes on soil loss and runoff rate. Hall Methods (1990) were used to select the size of simulated rain drop used in this experiment. For each drop size, kinetic energy is calculated according to the following:

$$KE = \frac{1}{2}mv^2$$

Where :

KE = Kinetic energy (joules)

M = mass (Kg)

V = impact viscosity from the graph as compared to those given by Guun and Kinzer (1949).

Each tray was exposed to rainfall 20 mm / hr rainfall for 30 minutes. Three replicates were conducted for each treatment. After such period the wash off was measured and the remaining soil was dried. After rewords soil loss and associated runoff were determined. Some properties of the investigated soils were determined according to FAO (1970) and Page et al. (1982) and Richard (1954). The soil properties of each site are given in (Table 1).

Table (1): Some properties of the studied soil samples.

Soil samples	p^H	EC (dSm^{-1})	$CaCo_3$ (%)	Particles size distribution (%)				Texture class
				C. sand	F. sand	silt	clay	
Fuka	7.93	0.9	28.2	20.8	32.6	22.8	23.8	Sandy clay loam
Wadi El Ramla	7.88	1.13	9.7	3.9	67.7	10.9	17.5	Sandy loam
Sidi Barrani	7.75	1.0	13.8	6.0	72.6	6.1	15.3	Sandy loam

Field Experiments:

The field experiments were carried out at west Matruh city,Wadi El Ramla for the evaluation of water erosion rate under different slope length under natural rainfall condition. Two experiments were carried out during two winter season (1998-1999 &1999-2000) . Soils of this area are sandy loam in texture with deep soil profile, Table (1). Slope of the experimental site is about 9 percent in south- north direction. The area climatic conditions is defined as arid Mediterranean type. It is characterized by short rainy seasons during October to March.The remaining period of the year is characterized by long dry season (6-7 months) except for rainy storms in April, May and September.

Unbounded runoff plots have a method of measuring sediment loss and runoff at the end of slope using Gerlesh trough with diameter 0.5 m long and 0.1 m broad closed at the sites and fitted with a moveable lid. An outlet pipe runs from the base of the gutter to a collecting bottle. The treatments were as follows :

1- Bare soil plots with three slope length 10, 20 and 40 m.

2- Cultivated plots with barley with three slope length (10,20 and 40 m). Three replicates were conducted for each treatment

Rainfall intensity (I mm hr^{-1}) was measured with an automatic rain gauge at the site of experiment. Rainfall amounts, duration and intensity were measured for each rainstorm.

The kinetic energy (E) of each storm was computed using rainfall charts supplied with the automatically recording rain gauge. According to Morgan (1995), the storm was divided into small time increments of uniform intensity. For each time period, kinetic energy for rainfall intensity was calculated using the following equation:

$$KE = 11.87 + 8.73 \log I$$

Where:

KE = kinetic energy($Jm^{-2}mm^{-1}$)

I = rainfall intensity(mm hr^{-1})

Prior to planting, natural vegetation on all plots were picked up, except for bare soil treatment. In the previously mentioned treatments , barley seeds (Hordieum vulgar L. c.v. saharawy,H ,100) were sown on November 1999 and 2000. Sowing was in rows spaced 10 cm at a rate of 60 kg /fed. Barley plants were harvested on April. The biological, straw and grain, yield was recorded for each plot.

The amount of soil loss for every rainstorm was determined by maintaining the containers undisturbed for a sufficient time so that the solid constitutions in the runoff water will precipitate. The supernatants were measurd volumetrically. Soil losses were measured gravimetrically after drying the precipitated soil constituents at 105°C over night.

RESULTS AND DISCUSSION

Laboratory Experiments:

Rainfall simulator experiments were carried out to evaluate the effect of some soil properties , drop size, kinetic energy and slope length on surface runoff and soil loss .Rainfall simulator was used to simulate rainfall on three samples (Fuka ,Wadi el Ramle and Sidi Barrani) collected from the north West Eastern Coastal Zone of Egypt . The soils are non saline mild to moderately alkaline .The soil texture varies between sandy loam to sandy clay loam. The $CaCO_3$ content ranges from 9.79% to 28.2%. Data presented in Table (1) reveal some properties of the studied soil samples.

Rainfall simulator was used to simulate rainfall intensity20mm/hr at constant slope 9% with four moisture content (air dry , -5bar , field capacity and saturation state) . Surface runoff and soil loss amounts were significantly affected by moisture content and soil properties as well as

the period of experiment ,Table (2). Variations in both moisture content and properties were significantly effective in the time required to initiation of runoff.

The date given in Table (2) illustrated that the largest time were required to initiation of runoff for dry condition and the lowest were for saturation condition. The decrease of water content may be caused an increase in infiltration rate and consequently the time required to runoff start. Truman and Bradford (1990) stated that differences in moisture content to initiate runoff between soils were observed .In general the wetting system required a lower time to initiate runoff than the drying system . They also reported that erosion hazard are highly depended upon soil moisture content and the time distribution of storm intensities.

For the 30 min of rainfall after runoff began surface runoff ($L.m^{-2}$) and sediment (gm^{-2}) computed for 10 , 20 and 30 min from all soils. The data on cumulative surface runoff and soil loss after 30 min of runoff began as function of time are shown in Table (2) & (3). Data reveal that the linear equation ($Y = a + b X$) was fitted to the experimental data , where Y is the amount of surface runoff(L/m^2) or soil loss (g/m^2) , X the time before runoff began and a&b are constants determined by using linear curve fitting technique. The data shows highly negative significant correlation coefficient between soil moisture and runoff or soil loss.

With respect to the effect of soil properties on soil erosion ,Table(2) shows that the decrease in soil loss under dry state of 30min erosion measurement interval for the studied soils. The data indicate that the major difference among three soils are texture, electrical conductivity, $CaCO_3$ content appear to be important factors causing differences in behavior of the three soils. In this respect, Singer *et al.* (1982) pointed out that the runoff volume increased significantly as exchangeable sodium percentage increased, probably because the seal formed reduced the infiltration rate decrease their aggregate strength and increased their detachability. Clay content to be important factors causing differences in behavior of soils. Table (2) also indicate that the lowest water erosion in Fuka soil followed by Sidi Barrani soil and largest value for Wadi el Ramla soil that is due to that Fuka soil contain clay and $CaCO_3$ content higher than the other soils.

Table (2): Effect of soil moisture content on wash erosion under three soil type

Moisture content \ Time	Fuka soil							Wadi ELRamla soil							Sidi Barany soil						
	Tr*	Runoff L/m²			Soil loss g/m²			Tr	Runoff L/m²			Soil loss g/m²			Tr	Runoff L/m²			Soil loss g/m²		
		10 min	20 min	30 min	10 min	20 min	30 min		10 min	20 min	30 min	10 min	20 min	30 min		10 min	20 min	30 min	10 min	20 min	30 min
Saturation State	1.5	15.6	24.5	36.4	238.1	572	845.9	1	19.9	31.9	43.7	437	679.6	968.8	1.2	20.1	32.7	40.3	403	628	876.1
F.C. 0.33	6.5	9.3	18.3	27.2	233	488.3	735.6	5.4	14.9	20.1	28.9	384.1	537.8	788	5.6	11.9	17.6	25.8	404	514	717.5
-5 bar	8.7	7.1	16.9	24.3	198.3	462	680.3	7.3	7.8	14.6	24.3	346.2	476.5	722	7.9	8.5	13.8	22.6	307.5	432.6	659.3
Air dry	11.8	4.3	12.7	20.1	102.2	331.1	513.2	9.6	5.9	12.9	19.5	290.5	391.4	623	10.1	4.6	16.7	21.5	242.1	337.6	532.7

Tr* :Time before runoff began (min)

Table (3): Linear equations for the relation between time before runoff began (X, min) and either surface runoff (Y, L m^{-2}) or soil loss (Y, g m^{-2}) for different sites.

Soil site	Correlation coefficients	Runoff	Soil loss
Fuka	a	38.56	914.67
	b	- 1.59	- 30.99
	r	- 0.9965	- 0.9698
Wadi El Ramla	a	45.7	1.008
	b	- 2.85	- 39.93
	R	-0.9937	- 0.9996
Barrany	a	41.06	926.5
	b	- 2.18	- 32.11
	R	-0.9641	- 0.9912

With regard to the effect of slope length on soil loss and runoff ,the results of soil loss and runoff are presented in Table (4) . it is clear that soil loss values increased by increasing slope length . The amount of soil loss increased by 19.8%, 49.8 and 77.6 by increasing slope length from 20 cm to 30 cm and 46 cm, respectively, as compared to 10 cm slope length . This is attributed to the fact that slope length increased the capability of the runoff to detach and transport the soil particles increased.

Table (4): Effect of different slope length on wash erosion.

Slope length (cm)	Runoff (L/m^2)	Soil Loss (g/m^2)
10	6.41	352.1
20	9.95	421.7
30	13.29	527.3
46	19.5	623.3

To evaluate the relationship between slope length with soil loss and runoff ,the correlation coefficients were 0.994 and 0.999, respectively, as linear form :

$Y = 276.9 + 7.71X$.
Where : Y= the amount of soil loss (g/m^2).
X= slope length (cm).
And $Y = 2.679 + 0.363X$.
Where : Y= runoff volume (L/m^2).
X= slope length (cm).

Similar mathematical expression was obtained by Tripathi and Singh (1993) . They stated that steepness and slope result in respective increases in velocity and volume of runoff . In this respect Goff et al. (1993) found that the increase in slope length had a linear relationship with the soil loss up to 30 m length after which slope length declined.

With regard to the effect of rainfall drop size on soil loss and runoff as affected by different drop sizes (1.4 , 2.3 and 3.7 mm),data are presented in Table (5). The data indicate that runoff varied between the three drop sizes by 5.1% and 12.3% at 2.3 and 3.7 mm, respectively, compared to drop size 1.4mm. Increasing drop size resulted in increasing runoff at constant rainfall intensity 20 mm/hr. Wherever, the soil loss varied between by 23.9% and 59.8% at 2.3 and 3.7 mm, respectively, compared to drop size 1.4 mm .

Table (5) : Effect of drop sizes and its kinetic energy on wash erosion.

Drop size (mm)	Kinetic energy ($K.J./m^2$)	Runoff (L/m^2)	Soil loss (g/m^2)
1.4	4.44	19.5	623.3
2.3	11.58	20.5	772.5
3.7	28.17	21.9	996.1

To evaluate the relationship between drop sizes and both runoff and soil loss . The results indicate that there were positive linear correlation and could be represented by the following equation :

Runoff (Lm^{-2}) = 18.1 + 1.01 drop size (mm) (r = 0.9996)
Soil Loss (gm^{-2}) = 397.99 + 161.88 drop size (mm) (r = 0.9999)

To reveal the data obtained in Table (4), rainfall kinetic energy was calculated and given for each drop size. The maximum kinetic energy reached 27.17kj/m² at 3.7mm drop size, while it reached 11.58 and 4.44 kj/m² at 2.3 and 1.4 mm drop size, respectively. Consequently as kinetic energy increased runoff and soil loss increased through increasing the ability of rainfall to detach soil aggregates. Meyer and Harmon (1985) reported that runoff water and soil loss increased as rain energy increased. These results are in good agreement with that obtained by Meyer and Harmon (1992).

Field experiment:

Precipitation Events Characteristics:

The depth and daily rainfall distribution during winter season (1999-2000) for the experimental site are given in Table (6). The total amount of rainfall is 140.6mm with rainy days. The rainy day is defined when the rainfall was >1 mm, Climateological Normals for the Arab Republic of Egypt (1979). Sixteen storms occurred only in the winter season. .Six storms were effective as they caused runoff and consequently soil loss. The total depth of rainfall for six storms was 71% of the total rainfall in the winter season. Rainfall intensities of the effective storms varied between 2.18 and 6.24 mm/hr. Hence, as the amount of rainfall increased runoff increased and vice versa. On the contrary, there was no relation between the number of rainy days and water erosion under the prevailing conditions during the present study. It is clear that runoff occurred when the depth of rainfall of the individual storm at any intensity exceeded 10mm.Similar results were also obtained by Hudson (1981). It is also evident that rainfall intensity gave no indication to the amount of runoff caused by the effective storm. The storm which exhibited 3.84 mm / hr rainfall intensity occurred on 12 / 12 /1999 caused appreciable depth runoff, whereas the storm of almost the same intensity 3.95 mm/hr which occurred on 31/10/1999 did not caused runoff because the amount of rainstorm less than

10 mm. Statistical analysis for the winter season indicated highly significant correlation coefficient between the depth of rainfall, rather than the rainfall intensity of the effective storms and both runoff and soil loss.

Table (6): Daily distribution of rainfall and runoff during study period.

Date	Rainfall			Runoff (mm)		
	Depth (mm)	Intensity (mm/hr)	Duration (hr)	Slope length (m)		
				10	20	40
23/10/99	10.9	2.18	5.0	0.5	0.55	0.61
31/10	3.5	3.95	5.7	-	-	-
13/11	18.2	4.04	4.5	0.9	0.94	1.1
21/11	16.5	3.59	5.25	0.8	0.83	0.86
2/12	2.9	0.27	10.7	-	-	-
6/12	3.5	0.67	5.25	-	-	-
12/12	14.4	3.84	3.75	0.72	0.74	0.77
29/12	3.2	0.19	17.2	-	-	-
31/12	26.5	6.24	4.25	1.3	1.36	1.4
3/1/2000	6.0	0.48	1.25	-	-	-
4/1	5.7	2.38	2.4	-	-	-
29/1	3.6	1.13	3.2	-	-	-
30/1	12.9	2.72	4.75	0.6	0.63	0.69
5/2	4.3	0.40	10.7	-	-	-
10/2	5.9	0.80	7.4	-	-	-
16/2	2.6	0.41	6.3	-	-	-
Total	140.6			4.82	5.05	5.43

To delineate such relationships under the conditions of the various treatments, the discussion will be presented as follows:

Runoff yield :

Table (7) shows the influence of plant cover treatment on the effective rainfall erosivity parameters. Data reveal that the total depth of runoff yield from the bare soil treatment, i.e., control, reached 4.82 mm, 5.05 mm and 5.43 mm for the three slope length indicating that average runoff

coefficient ,i.e. how much of rainfall run over the soil surface approaches 3.43%, 3.59% and 3.86%. These findings are in agreement with Viertman (1989), he mentioned that under the conditions of NWCZ of Egypt the runoff coefficient of 3% seasons reasonable. It can be concluded from the bare soil, the runoff will increase. The same conclusion is reached from planting treatments. Data also expected that the longer the duration of rain storm, regardless of the amplitude of the maximum kinetic energy, the high runoff will occur due to the decrease of soil infiltration capacity and / or the aid of soil slope. Table (7) indicated that the effective storms vary in rainfall intensity between 2.18 and 6.24 mm /hr and their kinetic energy from 183.3 to 568.7 Jm^{-2} and also rainstorm duration were 255 and 315 minutes besides runoff values were 0.5 and 1.4 mm, respectively.

Under all storms, it is clear that runoff values associated with bare soil was higher compared to planting treatment. The lowest runoff yield was recorded for 10 m slope length. Data in Table (7) indicate that runoff was reduced to 40.9 % for planting with barley plant as compared to bare soil at 10 m slope length , planting with barley plant with 20 m and 40 m slope length reduced runoff by 32.3% and 31.3%, respectively, as compared with bare soil. Similar results were given by khan et al. (1988) and Zuzet and Pikwl (1993),they reported that canopy straw mulch reduced runoff.

Simple correlation coefficient and regression equation were used to evaluate the relation between erosivity parameters and runoff yield under different levels of slope length for bare soil and cultivated soil. The results clear that there are significant positive linear relationship between runoff and erosivity parameters.

Table (7): Effect of some effective rainfall parameter for storms on runoff (mm) for three slope length under different treatments.

Date	Rainfall depth (mm)	Rainfall intensity (mm/hr)	Kinetic energy (J/m^2)	Runoff (mm)					
				Bare soil			Cultivated soil		
				Slope length (m)					
				10	20	40	10	20	40
23/10/1999	10.9	2.18	183.2	0.5	0.55	0.61	0.3	0.36	0.4
13/11	18.2	4.04	486.6	0.9	0.94	1.1	0.54	0.64	0.69
21/11	16.5	3.59	273.2	0.8	0.83	0.86	0.47	0.56	0.62
12/12	14.4	3.84	250.8	0.72	0.74	0.77	0.42	0.51	0.54
31/12	26.5	6.24	568.7	1.3	1.36	1.4	0.77	0.92	1.02
30/1/2000	12.9	2.72	234.6	0.6	0.63	0.69	0.35	0.43	0.46
Total		-	-	4.82	5.05	5.43	2.85	3.42	3.73

Soil loss:

The most important hazards resulted from water erosion is the removal of the soil from eroding surface. It is known that detachment and transport process of water erosion occur by raindrops and runoff. The influence of the applied planting treatment with three slope length on the amount of soil loss under natural rainfall intensities is given in Table (8). The highest rates of soil losses resulted from bare soil 1.75 , 2.45 and 2.97 ton/fed./year under 10, 20 and 40 m slope length, respectively. These rates lie within the permissible limits of soil loss by erosion which rang from 1 to 9 ton / acre / year, Hudson (1981). The results of soil loss for all rainstorms agrees well with the kinetic energy values, the highest soil loss were obtained from rain storm No. 5 , where kinetic energy increased. The highest kinetic energy gave the highest soil loss at every slope length .

With respect to planting with barley, it is clear that the amount of soil loss reduced by 41.8, 46.4 and 30% relative to bare soil for the three slope length. This behavior could be attributed to the fact that plant presheets, a portion of the soil surface from the energy of rainfall impact, thereby soil detachment decreased. Growing plants also create obstructions to water erosion to water flow over land, slowing down runoff velocity and

consequently its carrying capacity and thus reducing soil loss. Similar results were obtained by Gumbs and lindsay (1982).

Table (8): Effect of some effective rainfall parameters for storms on soil loss for three slope length under different treatments.

Date	Rainfall depth (mm)	Rainfall intensity (mm/hr)	Kinetic energy (J/m²)	Soil loss (ton/fed)					
				Bare soil			Cultivated soil		
				Slope length (m)					
				10	20	40	10	20	40
23/10/99	10.9	2.18	183.2	0.225	0.315	0.442	0.139	0.149	0.275
13/11	18.2	4.04	486.6	0.307	0.432	0.616	0.178	0.254	0.370
21/11	16.5	3.59	273.2	0.278	0.392	0.554	0.173	0.240	0.332
12/12	14.4	3.84	250.8	0.261	0.365	0.518	0.149	0.170	0.315
31/12	26.5	6.24	568.7	0.429	0.600	0.841	0.250	0.348	0.487
30/1/00	12.9	2.72	234.6	0.248	0.350	0.119	0.122	0.153	0.295
Total		-	-	1.751	2.456	2.965	1.019	1.316	2.077

Barley yield:

The aforementioned results prove that the planting with barley reduced the volume of runoff and soil losses. The values of grains and straw yield as well as the biological yield of barley affected by slope length are given in Table (9). It is clear that straw, grain and biological yield significantly decreased due to slope length increasing. Comparing between data presented in Table (8 & 9), it's clear that there are negative relation between soil loss and barley yield, where increasing slope length increased soil loss decreased barley yield. Table (6) indicate that the plant cover with barley plant reduce soil loss by 41.8% , 46.4 % and 30% for slope length 10,20,40m ,respectively. Similar results were obtained by Wassif et al. (1995),they reported that there are negative highly significant correlation between the biological barley yield with the amount of soil loss.

Table (9) Grain ,straw and biological yield as affected by slop length .

Slope length (m)	Straw (kg/fed)	Grain (kg/fed)	Biological yield (kg/fed)
10	2367.4	450.9	2818.3
20	2298.1	375.4	2673.5
40	2213.05	303.75	2516.8

CONCLUSION

It can be concluded that dividing slope length to 10 m apart could be recommended for controlling water erosion under rainfed agriculture.

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الملخص العربي

انجراف التربة بالأمطار بالساحل الشمالي الغربي بمصر

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أجريت تجربتان معملية وحقليه لتقييم معدل انجراف التربة بالأمطار بالساحل الشمالي الغربي بمصر. أجريت التجربة المعملية باستخدام جهاز المطر الصناعي بمركز بحوث الصحراء لدراسة تأثير بعض خواص التربة ومحتواها الرطوبي وطول الميل وحجم قطره المطر على كلا من كميه فاقد التربة وحجم الجريان السطحي. وأتضح من النتائج أن زيادة المحتوى الرطوبي بالتربة أدى إلى زيادة كلا من حجم الجريان السطحي وكميه فاقد التربة . كما تم إيجاد العلاقة بين كلا من كميه فاقد التربة وحجم الجريان السطحي مع الزمن قبل بداية حدوث الجريان السطحي .كما تم دراسة العلاقة بين طول الميل 10–20–30–46 سم على كلا من حجم الجريان السطحي وكميه فاقد التربة.

أجريت التجربة الحقلية غرب مدينه مرسى مطروح بالساحل الشمالي الغربي بمصر،بغرض تقييم العلاقة بين فاقد التربة وطول الميل والذي تراوح من 10 – 20 –40 م عند درجه ميل 9 % باستخدام الأحواض الغير محدده.

أظهرت النتائج أن كميه المطر خلال 16 عاصفة كانت 140.6مم، وأتضح أن معدل سقوط المطر الأقل من 10مم لم تؤدى إلى حدوث انجراف التربة. كما أتضح وجود اختلافات في حجم الجريان السطحي وكميه فاقد التربة عند زراعه الأرض بالشعير بالمقارنة مع عدم زراعتها .فقد أدت زراعه الأرض بالشعير إلى خفض معدل الجريان السطحي وفاقد التربة بنسبه 41.6% و40.6% على التوالي مقارنه بالأرض الغير منزرعة. بينما زادت كميه فاقد التربة وحجم الجريان السطحي بزيادة طول الميل. وكذلك تم تقييم العلاقة بين كمية فاقد التربة بالانجراف المائي وكميه المحصول.

أتضح من النتائج أهميه تقسيم طول الميل إلى أجزاء أصغر حتى يمكن التحكم في خفض مخاطر انجراف التربة بالمياه خاصة تحت ظروف الزراعة المطرية.



Soil Erosion By Wind in North Western Coastal Zone, NWCZ, of Egypt

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ABSTRACT

Mismanagement of soil, water and crop is the main reason for the wind erosion hazards, particularly under rainfed agriculture. Changes in surfaces soil structure during cultivation practices can increase soil loss by wind. This study was established to determine the rate of soil loss by wind erosion for Fuka area, NWCZ, Egypt during two years.

The study included seven treatments. The treatments are : (1) Intensive tillage for fig seedlings 30 cm high (ITF), (2) Minimum tillage for fig seedlings 30cm high (MTF), (3) Bare soil with tillage (BST), (4) Strip cropping (wheat and broad bean) and the plants harvested, pulled up by hand (SCP), (5) Strip cropping (wheat and broad bean), the crop residues were left after harvesting in the field (SCL), (6) Single broad bean (BB) and (7) Single wheat (W).

Samples of soil eroded materials were collected during the study period from four heights between 0.1 and 1.0 m above the soil surface using Big Spring Number Eight samplers. The quantity of soil loss varied according to sampling season, sampler height and treatments. The results show that the quantity of soil loss among treatments ranged between 2.29 and 10.17 t. ha^{-1}. yr^{-1}. The percent reduction in annual soil loss due to the (SCP), (SCL), (BB) and (W) treatments as compared to (BST) treatment as baseline option were 7.64, 38.64, 46.07 and 52.69 respectively. However, (ITF) and (MTF) treatments increased annual soil loss by 110.12% and 40.70% relative to (BST) treatment, respectively. Also the percent reduction in annual soil loss due to (MTF) treatment as compared to (ITF) treatment was 33.04.

It can be concluded that strip cropping or single cropping with leaving plant residues on soil surface are the best farming system for controlling the hazards of wind erosion under rainfed agriculture in NWCZ of Egypt. Also decreasing tillage practices (decreasing roughness factor) of soil for fig orchards lead to reduction in the rate of soil loss by wind.

INTRODUCTION

Soil and water are almost inextricably joined in the production of plants. NWCZ, Egypt, soils are characterized by high variability in nature, distribution and potentials. In this region, soils are subjected to wind erosion hazards because of soil surface devoid of vegetative cover, large fields, strong wind, drought is frequent and precipitation is low. The cultivated lands under dry farming system in NWCZ, consist of about 7.1% of the total area of the region, while a small area, 4000 feddans, of the irrigated agriculture land is present, FAO, UNDP (1970) and Troeh et al. (1980)

Wind soil erosion has some adverse effects on certain physical and chemical soil properties and on the productivity of the arable land. Rates

of soil loss accelerate quickly to unacceptably high levels whenever the land is misused. Wassif (1997) showed that the amount of soil eroded materials was 0.783 $t.m^{-1}$ width for bare soil of South Abou Lahu, NWCZ, Egypt through 93 days. Arroug (1994) found that predicted annual soil loss by wind in El-Omoyed area "NWCZ" of Egypt was 100 $t.ha^{-1}$ using WEQ, wind erosion equation according to Woodruff and Siddoway (1965). Sharkawy (1998) studied the effect of tillage system and land use on quantity and quality of soil loss by wind erosion for Fuka area, NWCZ, Egypt. He found that the measured annual soil loss ranged between 2.43 to 10.63 $t.ha^{-1}$ for different treatments. The enrichment ratio values of fertility constituents were greater than one.

The prevention of soil erosion, which means reducing the soil loss to approximately that occur under natural conditions, relies on selectiing suitable soil and crop management. Bilbro and Fryear (1985) and Zobeck et al. (1989) showed that different cropping and tillage methods produced different soil aggregate and wind erosion potentials. Unger and McCalla (1981) and Bilbro (1987) reported that the fallowing-cropping was effective in reducing potential wind erosion in semi-arid areas, which may have very little residue in the field after their harvest. Hagen and Armbrust (1992) found that threshold friction velocity depended on ridge height and spacing. Wassif et al. (2000) found that the threshold wind speed ranged between 6.1 and 6.6 $m.s^{-1}$ for the bare, dry soils of the NWCZ, Egypt.

In Egypt, field data is limited on the comparative effectiveness of soil conservation practices under rainfed agriculture. Therefore, this study was established at Fuka area, NWCZ, Egypt during two years to determine changes in dry soil aggregates as influenced by crop residues and tillage systems, as well as, annual soil loss for different cultivation and soil conservation practices.

MATERIALS AND METHODS

The study was established at Fuka area, NWCZ, Egypt, which located about 80 Km east of Mersa Matrauh. It is bounded by longitudes 27° 30′ - 28° 00′ E and latitudes 30° 30′ – 31° 00′ N. The experimental site is surrounded by 1.5 m height rubble-stone fencing and stony soil as non erodible area. Climateological data were obtained from recording automatic weather station placed 2 meters above the soil surface at the study site.

The treatments applied are: (ITF), Intensive tillage for fig seedlings 30 cm high, i.e., three times traditional tillage operation was conducted under rainfed agriculture conditions (Dec., Feb. and Apr.) with cleaning soil surface from natural vegetation. (MTF), Minimum tillage for fig

seedlings 30 cm high, i.e., tillage operation was conducted on December without removal natural vegetation from the soil surface. (BST), bare soil with tillage, the tillage operation was conducted on Dec (SCP), Strip cropping (wheat and broad bean) and the plants were harvested, pulling up by hand as followed under rainfed agriculture conditions. (SCL), Strip cropping (wheat and broad bean), the crop residues were left after harvesting on the soil surface. (BB), broad bean, the crop residues were left after harvesting. (W), wheat, the crop residues were left after harvesting .

An area of each treatment is 1 hectare (100X100 m) whereas soil was plowed by chisel plow to about 15 cm depth for every treatment. The tillage direction from west-north to east-south for all treatments as reported by Sharkawy (1998). The strip width is 33 m at strip cropping treatments as illustrated by Woodruff et al. (1972).

The amount of soil eroded particles was collected for 4 seasons; May-Oct.98, Nov.98-Apr.99, May-Oct.99 and Nov.99-April 2000 using Big Spring Number Eight traps (BSNE) at heights from 0.1 to 1.0 meter above soil surface as described by Fryrear (1986). Two traps were installed in each treatment to collect the eroded materials during different seasons at upward and leeward side of field. Eroded materials were dried at 55o for 72 hrs before weighing. The differences in the amount of eroded materials collected for each height above soil surface using BSNE samplers at upward and leeward sides were taken as the net amount of soil eroded materials transported by wind along field length.

Surface soil samples (0-5 cm) were collected from each treatment during different seasons. The soil samples for each treatment were mixed with each other to obtain representative seasonal sample. Particle size distribution using the pipette method, percentages of dry non-erodible aggregates > 0.84 mm and mean diameter (um), were determined according to Page et al. (1982) and USDA, SCS (1988).

Soil erodibility factor, I, was calculated according to Schwab et al. (1993). Soil surface roughness parameters, i.e., the heights of ridges and ridges spacing for different treatments were measured for different seasons and treatments. Then, soil roughness factor, k, using Woodruff and Siddoway (1965) method was determined. Also the vegetation parameters which included number of natural grown plants per feddan and their canopy diameters and the weight of surface and buried residues within 5cm depth, ($g.m^{-2}$) were determined according to Fryrear (1985). The percentage of soil cover calculated by Bilbro (1987 & 1989) method. The wind erosive energy factor,(WF, Wm^{-2}), was calculated using climateological data for Fuka area during the study seasons according to Fryrear et al. (1994).

RESULTS AND DISCUSSION

Soil Properties:

The field surface of the study area is almost flat. The soil depth is shallow (<1m). The stones is present at the soil surface at almost 10%. The predominant soil type is Typic Calcic. Soil texture is sandy clay loam. Sand content is higher than 50%. The silt / clay content was less than 10 percent. Organic matter content is low. Soil reaction is moderately alkaline. Soil salinity values were very low. The soil is low in fertility, Table (1). From these data we can reported that the soil was easily eroded, very susceptible to erosion by wind and the tolerable loss is 2 t. ha^{-1}. yr^{-1} for these soils according to Wilson and Cooke (1980) ,Troeh et al. (1980) and Ticknor (1987). They reported that wind erosion is a problem where soil movement exceeds the tolerable loss, 2 t. ha^{-1}. yr^{-1} is for shallow soils having unfavorable subsoil and parent materials that severely restrict root penetration and development.

Climate Characteristics:

Climate data were measured at 2-m height above soil surface. Data in Table (2) show that the mean temperature varied from 15.27°C in second season (Nov. 98-Apr. 99) to 24.2°C in first season (May-Oct. 98). It is noticed that its values in fallow seasons (May-Oct.) are 1.6 times higher than in growing seasons (Nov.-Apr.). Total annual precipitation during winter seasons 1998/1999 and 1999/2000 reached 121.90mm and 84.81mm, respectively. Data show that the fallow seasons (May- Oct.) were almost dry and the growing seasons (Nov.-Apr.) are rainiest. Therefore, such area is under arid and semi-arid conditions with Torric soil moisture regime and Thermic temperature regime. The dryness prevails through most of the year and the wet periods are comparatively small.

With regard to the wind characteristics, hourly wind speeds varies from 0.2 $m.s^{-1}$ to 14.01ms^{-1} during the study period (May 1998-Apr. 2000). The average wind speed varies from 3.69$m.s^{-1}$ during the first season (May-Oct.98) to 3.80 $m.s^{-1}$ during fourth season (Nov.98-Apr.2000). Hours number of wind speed > 6$m.s^{-1}$ (measured active wind speed) represented 14.4% of the time during 2 year (May 98 - Apr. 2000). The wind erosive factor (WF, $W.m^{-2}$) has been calculated from the equation described by Fryrear et al. (1994) and Sterk (1994): $WF = (\Sigma\rho V (V-V_t)^2)/N$, where : V is the average wind velocity at 2m above soil surface ($m.s^{-1}$); V_t is threshold wind velocity (6$m.s^{-1}$, as reported by Wassif et al. 2000); ρ is the density of air (approximately 1.2 kg m^{-3}) and N is number of wind speed observations with V > Vt. Data in Table (2)

show that the wind erosive factor (WF) varied between seasons. The wind erosive factor was relatively greater for growing seasons (Nov. - Apr.) compared to fallow seasons (May-Oct.). The wind erosive factor is dependent upon the number of hrs wind speed > $6 m.s^{-1}$ and the frequency of wind speeds exceeded $6 m.s^{-1}$. Therefore, the most erosive season during the year occurred from Nov. through Apr. (growing season) in NWCZ of Egypt.

Soil Wind Erosion:

Eroded soil particles collected by BSNE traps during the four seasons from May 1999 to April 2000 at 0.1, 0.5, 0.75 and 1 meter heights above soil surface for the various treatments are listed in Table (3). Data reveal that the quantity of eroded soil particles decreased by increasing sampler height, Fig. (1). Consequently, the bulk of the eroded soil particles carried close to the soil surface. This phenomenon verified by the results obtained by Fryrear (1986), Fryrear and Saleh (1993), Wassif et al. (1997) and Sharkawy (1998).

Data in Table (3) show that the amount of eroded soil particles collected during the growing seasons (Nov. - Apr.) was greater for every treatment than that collected from the fallowing seasons (May - Oct.) It is anticipated that the differences in the amount of eroded soil particles between treatments and seasons are related to the effect of erosive wind action, soil surface conditions. Chepil (1959) reported that the increase of erosion across an erodible surface is a function of the soil surface conditions.

The relationships between amounts of eroded soil particles ($Y, g.cm^{-2}$) and height above soil surface (X, meter), Table (3), were tested using regression models. It was found that the power functions ($Y=aX^b$) are recommended to be used to describe such function. The fitted equations were significant at the 0.01 and 0.05 significant levels, with very few exceptions. In this respect, previous studies (Fryrear, 1986; Fryrear and Saleh, 1993; Wassif et al., 1997 and Sharkawy 1998) reported that power expression described the quantity of eroded materials transported by wind above the soil surface in the field. In this study, the amounts of eroded soil particles above one meter and creep component not recorded because the first one was expected to be negligible and most of the creeped particles will be redistributed within the field, particularly towards leeward on rough soil surface, as previously stated by Sterk (1994) and Sharkawy (1998).

Table (1): Some soil properties measured during study season (May 1998 – Apr. 2000) at Fuka area, NWCZ, Egypt.

Soil depth (cm)	Particle size distribution with $CaCO_3$			Texture class	pH	EC ($dS.m^{-1}$)	$CaCO_3$ (%)	O.M. (%)	CEC ($cmol.kg^{-1}$)*
	Sand %	Silt %	Clay %						
0 – 5	53.87	23.50	22.63	Sandy clay loam	7.67	1.12	26.30	0.37	23.70
5 – 30	55.97	21.80	22.23	Sandy clay loam	7.90	1.03	27.40	0.30	21.90
30 – 60	52.43	22.44	25.13	Sandy clay loam	8.00	0.97	28.30	0.27	20.80

* 1 centimol.kg^{-1} = 1 meq. $100gm^{-1}$.

Table (2): Climateological data* measured during different study seasons at Fuka area, NWCZ, Egypt.

Measurement seasons	Av. Temperature (°c)	Rainfall amount (mm)	Wind Speed ($m.s^{-1}$)	wind speed (> 6 $m.s^{-1}$)		Wind erosive factor ($W.m^{-2}$)
				No. of hrs.	% of time	
May-Oct. 98 (First season)	24.20	8.7	3.69 (0.2 – 14.01)	583	13.2	20.89
Nov.98 - April 99 (Second season)	15.27	113.2	3.70 (0.2 – 13.87)	623	14.3	36.12
May-Oct. 99 (Third season)	23.7	3.84	3.70 (0.2 – 13.50)	688	15.6	29.07
Nov.99-April 2000 (Fourth season)	14.80	80.97	3.80 (0.2 – 13.96)	635	14.5	44.83

* Climateological data measured at 2-m height.

The total amount of eroded soil particles (Q, $kg.m^{-1}$ width) was obtained by integrating the fitted power equations over heights from 0.1 to 1.0 meter above the soil surface, Table (4). Data reveal that the amount of eroded soil particles for every season depended upon the soil cover percent, buried crop residues ($g.m^{-2}$), soil surface roughness factor (K', dimensionless) and soil erodibility (I, $t.ha^{-1}.yr^{-1}$), which varied between treatments from season to another.

A discussion of the seasonal distribution of soil loss due to wind leads naturally to discussion when and where soil wind erosion is most sever and what are the farmers working to reduce soil loss from their agriculture fields. Concerning, the effect of wind erosive factor, it can be seen that the amount of eroded soil particles during first season (May 98-Oct.98) were much lower than during the other seasons. Whereas, the amount of eroded soil particles during fourth season (Nov.99-Apr. 2000) were the greatest. The amount of eroded soil particles during growing seasons (Nov.-Apr.) was greater than during the fallow seasons (May-Oct.). Therefore, the growing seasons (Nov.-Apr.) reflected the presence of very active erosive wind (av. WF = 40.48 $W.m^{-2}$) and very active erosion process, Fig.(2). It is found that the soil cover percent, buried crop residues ($g.m^{-2}$) and soil erodibility (I, $t.ha^{-1}$) during growing seasons (Nov.-Apr.) were the greatest, whereas the soil surface roughness (K', dimensionless) only decreased. Table (4) depicted that the amount of soil aggregates > 0.84mm (%) and mean diameter of particles (μm) during growing seasons (Nov.-Apr.) were relatively smaller than that during fallow seasons (May-Oct.). The overall range of soil aggregates > 0.84 mm (%) and mean diameter of particles (μm) in the soil surface layer (0-5 cm) were 11.82 - 55.92 and 173 - 283, respectively. The average soil erodibility factor (I, t. ha^{-1}) for growing and fallow seasons are 121.67 and 103.96, respectively. In this respect, Pasak (1974) showed that soils with content of non-erodible particles (> 0.84 mm) exceeding 60% were considered as soil resistant to wind erosion. From this data it can be concluded that the highest amounts of soil loss during growing seasons (Nov.-Apr.) are mainly attributed to two main factors. The first one is very active erosive wind (WF) and the second is the soil erodibility(I).

Table (3) Amount of eroded soil materials (g cm^{-2}) collected during the study seasons using BSNE samplers at Fuka area, NWCZ, Egypt.

Treatments*	Height (m)	1/5 - 31/10/98**	1/11/98 - 30/4/99	1/5 - 31/10/99**	1/11/99 - 30/4/2000	Total
(IF)	0.10	0.789	22.044	8.085	62.221	93.139
	0.50	0.355	11.168	2.009	6.014	19.546
	0.75	0.219	6.671	1.297	4.023	12.210
	1.00	0.140	3.857	1.022	3.208	8.227
(MTF)	0.10	0.700	12.635	6.703	20.020	40.058
	0.50	0.333	4.360	1.216	8.292	14.201
	0.75	0.238	3.580	0.891	6.800	11.509
	1.00	0.127	1.419	0.700	4.889	7.135
(BST)	0.10	0.707	10.655	6.093	18.653	36.108
	0.50	0.196	3.209	1.049	4.877	9.331
	0.75	0.114	2.375	0.842	3.344	6.675
	1.00	0.088	1.581	0.622	1.992	4.283
(SCP)	0.10	0.387	5.220	4.545	8.783	18.935
	0.50	0.286	2.432	1.580	5.800	10.098
	0.75	0.179	1.844	1.244	5.280	8.547
	1.00	0.120	1.258	0.773	3.890	6.041
(SCL)	0.10	0.396	3.947	1.763	6.597	12.703
	0.50	0.207	2.704	1.133	2.975	7.019
	0.75	0.118	2.112	0.706	2.300	5.236
	1.00	0.094	1.598	0.513	1.820	4.025
(BB)	0.10	0.357	3.308	1.829	7.309	12.803
	0.50	0.154	1.942	0.825	2.517	5.438
	0.75	0.113	1.530	0.622	2.030	4.295
	1.00	0.085	1.264	0.422	1.872	3.643
(W)	0.10	0.700	3.357	1.423	3.624	9.104
	0.50	0.140	2.270	0.782	2.587	5.779
	0.75	0.100	1.635	0.589	1.608	3.932
	1.00	0.087	1.413	0.444	1.300	3.244

*** Treatments are:**

(ITF) : Intensive tillage for fig seedlings 30cm high.

(MTF) : Minimum tillage for fig seedlings 30cm high

(BST) : Bare soil with tillage.

(SCP) : Strip cropping (wheat and broad bean) without plant residues.

(SCL) : Strip cropping (wheat and broad bean) with plant residues.

(BB) : Single broad bean.

(W) : Single wheat.

** The cultivation and tillage practices were not conducted at these seasons.

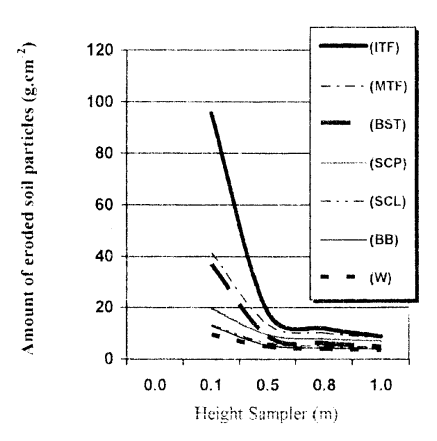


Fig (1) Estimated amount of eroded soil particles ($g.cm^{-2}$) at four heights during the study season (May, 1998-April, 2000).

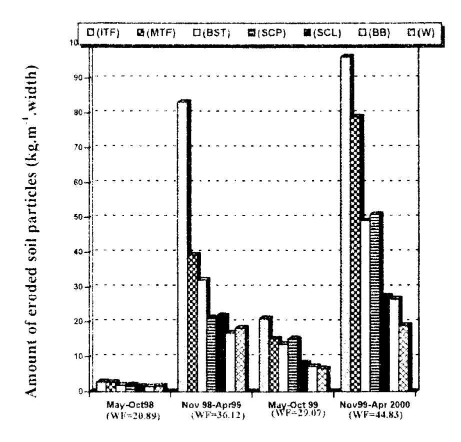


Fig. (2). Amount of eroded materials (Q, $kg.m^{-1}$ width) for different treatment during the study seasons.

Table (4) Soil loss as influenced by Wind erosive factor, Soil properties, and field measurements during different study seasons at Fuka area.

Treatments*	Wind erosive factor (WF, $W.m^{-2}$)	Soil cover (%)	Buried crop residues ($gm.m^{-2}$)	Roughness factor (k',dimensionles)	Mean diameter (μm)	Aggregates > 0.84-mm (%)	Soil erodibility (I, $t.ha^{-1}.yr^{-1}$)	Soil loss (Q, $Kg.m^{-1}$ width)***
First season (May - Oct. 98)**								
(ITF)	20.89	0.90	6.15	0.87	195	25.19	191.69	2.85
(MTF)		1.03	7.8i	0.85	186	28.20	179.95	2.68
(BST)		1.30	7.65	0.65	260	41.34	100.48	1.89
(SCP)		1.80	7.15	0.63	265	39.18	109.55	1.99
(SCL)		1.40	5.18	0.63	283	45.55	84.91	1.60
(BB)		1.82	6.14	0.60	278	48.18	76.43	1.40
(W)		1.70	5.50	0.60	280	50.81	68.80	1.70
Second season (Nov. 98 - Apr. 99)								
(ITF)	36.12	0.50	8.50	0.76	173	18.78	247.71	83.19
(MTF)		1.65	11.97	0.65	195	35.18	128.55	39.33
(BST)		3.50	8.12	0.54	238	39.82	106.78	32.17
(SCP)		10.50	19.50	0.51	257	38.15	114.15	21.33
(SCL)		12.90	45.80	0.52	273	52.15	65.21	21.96
(BB)		11.12	35.16	0.50	268	50.41	69.91	16.87
(W)		10.40	42.92	0.52	268	50.14	70.67	18.36
Third season (May - Oct. 99)**								
(ITF)	29.07	0.60	7.90	0.95	200	28.00	171.32	21.14
(MTF)		1.87	19.11	0.80	205	40.72	103.00	15.17
(BST)		1.50	18.12	0.65	253	47.15	79.46	13.69
(SCP)		1.82	6.14	0.70	263	40.18	105.25	15.23
(SCL)		3.53	33.18	0.65	280	55.92	56.08	8.35
(BB)		3.87	20.08	0.60	268	50.12	70.73	7.28
(W)		4.48	29.07	0.58	272	55.16	57.81	6.65

Cont. Table (4) Soil loss as influencd by Wind erosive factor, Soil properties, and field measurements during different study seasons at Fuka area.

Treatments*	Wind erosive factor (WF, $W.m^{-2}$)	Soil cover (%)	Buried crop residues ($gm.m^{-2}$)	Roughness factor (k',dimensionles)	Mean diameter (um)	Aggregates > 0.84-mm (%)	Soil erodibility (I, $t.ha^{-1}.yr^{-1}$)	Soil loss (Q, $Kg.m^{-1}$ width)***
Fourth season (Nov.99 - Apr. 2000)								
(ITF)	44.83	0.50	7.67	0.98	178	11.82	327.22	96.19
(MTF)		2.20	12.90	0.76	210	33.48	137.60	79.03
(BST)		2.50	10.80	0.57	250	37.48	117.26	49.04
(SCP)		5.40	16.80	0.55	248	35.50	126.92	50.86
(SCL)		6.15	35.90	0.51	273	54.55	59.24	27.46
(BB)		5.40	28.12	0.52	265	53.68	61.34	26.63
(W)		7.95	33.90	0.52	270	51.98	70.77	18.99

* **Treatments are:**

(ITF) : Intensive tillage for fig seedlings 30cm high.

(MTF) : Minimum tillage for fig seedlings 30cm high

(BST) : Bare soil with tillage.

(SCL) : Strip cropping (wheat and broad bean) with plant residues.

(SCP) : Strip cropping (wheat and broad bean) without plant residues

(BB) : Single broad bean.

(W) : Single wheat

** The cultivation and tillage practices were not conducted at these seasons.

****Soil loss calculated by power equation ($Y=aX^b$),where Y=amount of eroded materials collected by BSNE samplers (g cm-2) at height above soil surface (X , m) and a & b are regression coefficients .

As shown in Table (5), the amount of eroded soil particles for every season depended upon the soil cover percent, buried crop residues ($g.m^{-2}$), soil surface roughness ($K^{/}$, dimensionless), and soil erodibility (I, $t.ha^{-1}.yr^{-1}$), which varied between treatments from season to another. Data show that there was great difference in amount of eroded soil particles. It is clear that the intensive tillage for fig seedlings 30cm high treatment (ITF) resulted in the greatest amount of eroded soil particles (203.37 kg m^{-1} width) during 2 years (May 98-Apr 2000), followed by minimum tillage for fig seedlings 30cm high (MTF), bare soil with tillage (BST), strip cropping (wheat and broad bean) without plant residues (SCP), strip cropping (wheat and broad bean) with plant residues (SCL), single brad bean (BB) and single wheat (W) treatments, respectively.

The highest amount of eroded soil particles collected from (ITF) treatments is attributed to intensive tillage conducted by farmer for fig orchards to conserve water in the soil, smoother soil surface, higher soil erodibility ($I^{/}$, $t.ha^{-1}.yr^{-1}$), higher soil surface roughness factor ($K^{/}$ dimensionless) and insufficient soil cover percent. The lowest amount of eroded soil particles collected from (W) treatment is attributed to the presence of plant residues left after crop harvesting, buried crop residues ($g.m^{-2}$), higher soil cover percent, lower soil surface roughness factor ($K^{/}$) and lower soil erodibility ($I^{/}$). Data in Table (5) reveal that as the wind erosive factor (WF) is increased in growing seasons (Nov.-Apr.), the amount of eroded soil particles is increased. This is supported by Fryrear et al. (1991), Saleh (1994), Fryrear (1995), Moldenhaure and Duncan (1969), Sutherland et al. (1991) and Unger and McCalla (1981).

Table (5) Amount of eroded materials (Q, $Kg.m^{-1}$ width) as influenced by different treatments and wind erosive factors ($WF, W.m^{-2}$) during study season (May 1998 -- Apr. 2000).

Treatments* and seasons	Soil erodibitily ($I, Ton.ha^{-1}.yr^{-1}$)	roughness factor ($K^{/}$, dimenionless)	Soil cover (%)	Buried crop residues ($gm.m^{-2}$)	Wind erosive factor ($WF, W.m^{-2}$)	Eroded materials ($Q, Kg.m^{-1}$ width)
ITF	234.49	0.89	0.60	7.56		203.37
MTF	137.28	0.77	1.69	12.95		136.21
BST	101.00	0.60	2.20	11.17		96.79
SCP	113.97	0.60	4.88	12.40		89.41
SCL	66.36	0.58	6.00	30.02		59.37
BB	69.60	0.56	5.55	22.38		52.18
W	67.01	0.56	6.13	27.85		45.70
May-Oct.98					20.89	2.02
Nov 98-Apr.99					36.12	33.36
May-Oct.99					29.07	12.50
Nov 99-Apr.2000					44.83	49.74

For getting a better understanding of the relationship between amount of eroded particles and factors affecting soil wind erosion, two tests were done. In the first test, regression equations and correlation coefficients relating the amount of soil eroded particles (Q, $kg.m^{-1}$ width) with wind erosive factor (WF, $W.m^{-2}$), soil erodibility factor ($I, t.ha^{-1}.yr^{-1}$), soil surface roughness (K', dimensionless), soil cover percent, and buried crop residues ($g.m^{-2}$) were calculated. The fitted regression equations are.

(1) $Y = 2.07\,(WF) - 43.42$ $(r = 0.99^{**})$

(2) $Y = 0.92\,(I) - 6.19$ $(r = 0.98^{**})$

(3) $Y = 427.21\,(K') - 180.72$ $(r = 0.97^{**})$

(4) $Y = 1206.92\,(BCR)^{-0.957}$ $(r = -0.92^{**})$

(5) $Y = 166.09 - 62.23 \ln (SC)$ $(r = -0.97^{**})$

Where (Y)= amount of soil eroded particles ($kg.m^{-1}$ width),
(WF)= wind erosive factor ($W.m^{-2}$),
(I')= soil erodibility ($t.ha^{-1}.yr^{-1}$),
(K')= soil surface roughness (dimensionless),
(SC)= soil cover percent,
and (BCR = buried crop residues ($g.m^{-2}$).
These equations were choosing according to their significance. The reason for such choice is based upon the fact that the estimated response should not loose its suitability for application. The(r) values were highly significant. The correlation coefficient values (r) indicated that the amount of eroded particles ($kg.m^{-1}$ width) increased linearly with increasing wind erosive factor (WF, $W.m^{-2}$), soil erodibility (I, ton.ha.yr), and soil surface roughness (K', dimensionless). The amount of eroded particles ($kg.m^{-1}$ width) increased logerthemly and powerly with decreasing buried crop residues ($g.m^{-2}$), and soil cover percent, respectively, Figs. (3, 4, 5, 6 &7).

In the second test, multiple regression test was used for evaluating amount of eroded particles with soil erodibility ($I, t.ha^{-1}.yr^{-1}$), soil surface roughness (K', dimensionless),buried crop residues (BCR, $g.m^{-2}$) and soil cover percent (SC). The fitted equation is:

Soil loss = $-8.61083+0.48349^{*}$(Soil erodibility)$+116.439^{*}$(Roughness factor)-5.7511^{*}(Soil cover)-0.111844^{*}(Buried crop residues) $(r^2 = 0.95^{**})$

The (r^2) values were highly significant.

The above-mentioned equations can be used to predict the wind blown materials collected between 0.1 and 1.0 meters above soil surface with minimum variance of prediction error.

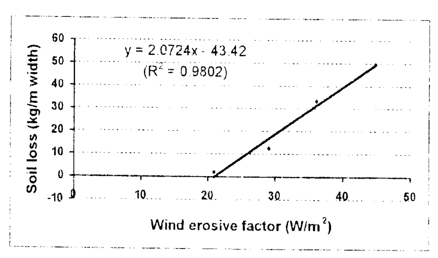


Fig. (3): Regression model of wind erosive factor versus amount of eroded materials during four study seasons.

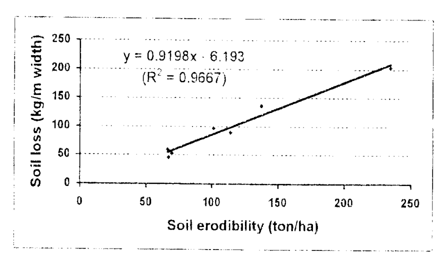


Fig. (4): Regression model of soil erodibility versus amount of eroded materials during study season (May 98-Apr. 2000).

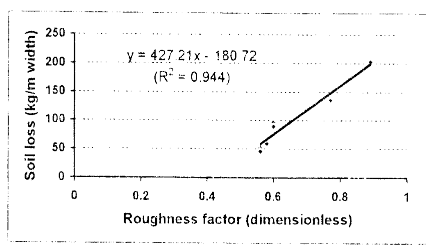


Fig. (5): Regression model of soil roughness factor versus amount of eroded materials during study season (May 98-Apr. 2000).

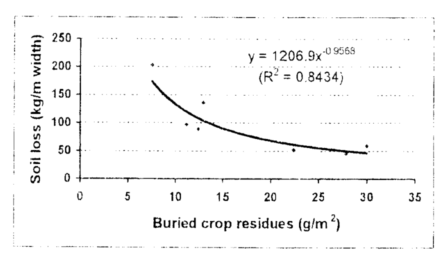


Fig. (6): Regression model of buried crop residues versus amount of eroded materials during study season (May 98-Apr. 2000).

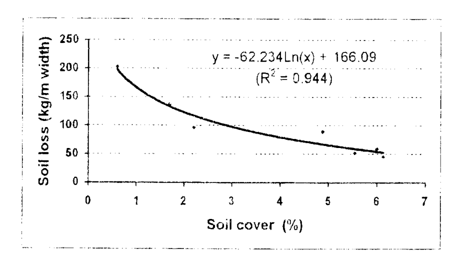


Fig. (7): Regression model of soil cover percent versus amount of eroded materials during study season (May 98-Apr. 2000).

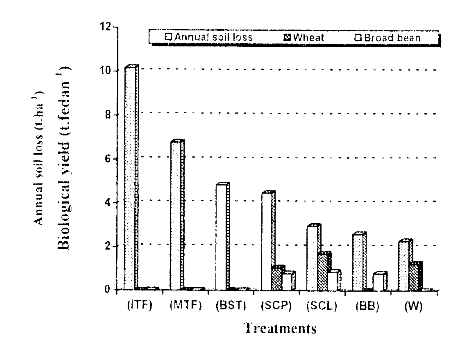


Fig.(8): Average Annual soil loss and biological yield for different treatments during the study season (May, 1998-April, 2000).

The average annual soil loss due to wind erosion for different treatments at Fuka area, NWCZ, Egypt are listed in Table (6). The treatment (ITF) with intensive tillage practice produced an average annual soil loss of 10.17 $t.ha^{-1}$. For the treatment (MTF) with minimum tillage practice, the annual soil loss was 6.81 $t.ha^{-1}$. Therefore, decreasing tillage practices (decreasing soil surface roughness factor, K') for fig orchards led to reduction in annual soil loss by 33.04%. However, (ITF) and (MTF) treatments increased annual soil loss by 110.12% and 40.70% relative to (BST) treatment, respectively. Annual soil loss across treatments (SCP), (SCL), (BB) and (W) treatments were only 0.92, 0.61, 0.54 and 0.47 that of (BC) treatment as baseline option. This is attributed to the highest amount of plant residues which left in the field after crops harvesting, the highest percentage of soil aggregates > 0.84 mm and the lowest amount of soil surface roughness factor. The strip cropping treatment (SCL) with left crop residues on the soil surface decreased annual soil loss by 33.56% as compared to strip cropping treatment (SCP) without crop residues. Annual soil loss averaged across single cropping treatments (BB) and (W) (2.45 $t.ha^{-1}.yr^{-1}$) was only one-half that of treatment (BST). In this respect, Chepil and Woodruff (1963) reported that proper tillage and cropping practices are required if moisture conserved and erosion curtailed. Tripathi and Singh (1993) and Bilbro et al. (1994), concluded that excessive tillage leads to severe wind erosion in arid areas. Single and strip cropping treatments will produce enough residues to adequately protect the soil. Even small amounts of residues, such that produced by some dry land crops, can be significant benefit in controlling wind and water erosion.

Crops Yield:

Data in Table (6) show that treatments applied had a significant effect on grain, straw and biological wheat and broad bean yields. It is clear the wheat and broad bean yields are affected by the rainfall amount. Therefore, the amount of wheat yields was lower for growing season (Nov. 99 – Apr. 2000) than that for growing season (Nov. 98 – Apr. 99), Table (6). The broad bean yields were not produced during the growing season (Nov.99–Apr.2000), amount of rainfall equal 84.81mm.

The contribution of soil loss in wheat biological yield reduction were (16% & 2% and 9% & 3%) for (SCP) and (SCL) treatments, respectively during the growing seasons (Nov. 98 – Apr. 99) and (Nov. 99 – Apr. 2000) compared to (W) treatment, respectively. However, the broad bean biological yield reached 9.5% and 8.9% during growing season (Nov. 98 – Apr. 99) for (SCP) and (SCL) treatments compared to (B) treatment, respectively. (SCL) treatment increased wheat and broad bean yields compared to (SCP) treatment. Further studies should be conducted to

study the relationship between amount soil loss and crop yields under rainfed agriculture conditions.

Table (6) Influence of applied treatments on annual soil loss (ton. ha^{-1}. yr^{-1}) and biological yield.

Treatments*	Av. annual soil loss		(SLR)****	Biological yield (Kg / Feddan)			
				Wheat		Broad bean	
	Kg m^{-1} width**	Ton. ha^{-1}***		straw	grains	straw	grain
(ITF)	101.69	10.17	2.10				
(MTF)	68.11	6.81	1.41				
(BST)	48.40	4.84					
(SCP)	44.71	4.47	0.92	765.12*****	643.18*****	252.16*****	525.8*****
				388******	350.18******		
(SCL)	29.69	2.97	0.61	855.9*****	799.18*****	265.89*****	517.33*****
				375******	410.75******		
(BB)	26.09	2.61	0.54			285.75*****	573.9*****
(W)	22.85	2.29	0.47	838*****	842.12*****		
				412.5******	399.18******		

***Treatments are:**

(ITF): Intensive tillage for fig seedlings 30-cm high.

(BST): Bare soil with tillage.

(MTF): Minimum tillage for fig seedlings 30-cm high

(BB): Single broad bean.

(SCP): Strip cropping (wheat and broad bean) without plant residues.

(W): Single wheat.

(SCL): Strip cropping (wheat and broad bean) with plant residues.

** The amount of soil loss passing a strip of 1-m along the field length at 1-m above soil surface

*** The amount of soil loss transported from an area (100 x 100 meter) at 1-m above soil surface

****SLR: Soil loss from any treatment divided by soil loss from bare soil with tillage treatment

*****Biological yield determined during second season.

******Biological yield determined during fourth season.

CONCLUSION

A discussion of the seasonal distribution of soil loss due to wind leads naturally to discussion when and where soil wind erosion is most sever and what are the farmers working to reduce soil loss from their agriculture fields. From this study it can be concluded that growing season reflected the presence of very active erosion process compared to fallow season at NWCZ of Egypt. The excessive tillage and cleaning soil surface from natural vegetation and plant residues often causes excessive soil loosening and pulverization and leads to excessive soil loss by wind

erosion. Two factors (soil erodibility factor ,I and wind erosive factor, WF) play the importance role in wind erosion process at NWCZ. A good linear relationship between amount of soil eroded particles (Q, kg.m^{-1} width) with soil erodibility factor, soil roughness factor, and wind erosive factor was evident. Whereas, a good logarithmic and power relationships were reported between amount of soil loss (Q, kg.m^{-1} width) and soil cover residues, and buried crop residues respectively. These fitted equations are interesting for studying temporal variability of wind erosion processes. The importance of preventing wind erosion during growing season by making better crop and soil management practices. Minimum tillage for fig orchards and strip cropping or single cropping with leaving plant residues on the soil surface is the best farming system for controlling the hazards of wind erosion

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الملخص العربي

انجراف التربة بالرياح بالساحل الشمالي الغربي بمصر

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من الأسباب الرئيسية لمخاطر الانجراف بالرياح تحت ظروف الزراعة المطرية هي عمليات خدمة التربة والإدارة الزراعية الغير مناسبة 0 وتؤدى الاختلافات في بناء سطح التربة أثناء عمليات الزراعة إلى زيادة معدلات فاقد التربة بالرياح 0 أقيمت هذه الدراسة لمدة عامين بغرض تقدير معدل فاقد التربة بالانجراف بالرياح بمنطقة فوكة بالساحل الشمالي الغربي بمصر.

شملت هذه الدراسة سبعة معاملات هي: (1) معاملة الحراثة الكثيفة لأرض منزرعة شتلات تين ارتفاعها 30 سم (**ITF**)، (2) معاملة الحد الأدنى من الحراثة لأرض منزرعة شتلات تين ارتفاعها 30 سم (**MTF**)، (3) معاملة الحراثة للأرض البور بدون زراعة (**BST**)، (4) معاملة الزراعة الشرائطية (قمح وفول بلدي) مع حصاد المحاصيل بالخلع باليد (**SCP**)، (5) معاملة الزراعة الشرائطية (قمح وفول بلدي) مع ترك بقايا المحصول بعد الحصاد في الحقل (**SCL**)، (6) معاملة زراعة الفول البلدي منفردا (**BB**) و(7) معاملة زراعة القمح منفردا (**W**).

جمعت عينات مادة التربة المنجرفة بالرياح خلال فترة الدراسة على أربع ارتفاعات من 0.1 إلى 1 متر أعلى سطح التربة باستخدام مصائد تجميع المادة المنجرفة بالرياح (**BSNE**) وقد اختلفت كمية فاقد التربة تبعا لفترة القياس والارتفاع عن سطح التربة والمعاملات المستخدمة.

أشارت النتائج إلى أن كمية فاقد التربة المنجرفة بالرياح تراوحت من 2.29 إلى 10.17 طن / هيكتار / سنة للمعاملات المستخدمة .وبلغت النسبة المئوية للانخفاض في المعدل السنوي لفاقد التربة نتيجة لمعاملات (**SCP**) ، (**SCL**) ، (**BB**) ، (**W**) مقارنة لمعاملة (**BST**) 7.64، 38.64، 46.07 ، 52.69 على التوالي. بينما أدت معاملات (**ITF**) ، (**MTF**) إلى زيادة كميات فاقد التربة السنوية بنسب 110.12% ، 40.70% بالنسبة إلى معاملة (**BST**) على التوالي . أيضا بلغت النسبة المئوية للانخفاض في المعدل السنوي لفاقد التربة نتيجة لمعاملة (**MTF**) مقارنة بمعاملة (**ITF**) 33.04 .

يمكن التوصية بأن معاملات الزراعة الشرائطية أو زراعة المحاصيل (الفول أو القمح) منفردة مع ترك البقايا النباتية على سطح التربة هي افضل نظم الزراعة تحت ظروف الزراعة المطرية بغرض مقاومة مخاطر الانجراف بالرياح في الساحل الشمالي الغربي بمصر . أيضا تقليل عمليات الحراثة (زيادة معامل الخشونة لسطح التربة) لحدائق الزيتون تؤدي إلى تقليل معدل فاقد التربة بالرياح .

Agrometeorology and Its Relation to Probability of Desertification in EL-Ahariya Depression, Western Desert –Egypt.

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ABSTRACT

The current study carried out during 2001 at El-Baharyia depression in the western desert of Egypt, to estimate soil loss by using wind erosion equation and its effect on soil physical, chemical and soil fertility for the studied area. Also, to evaluate the level of soil desertification and its control.

The obtained results showed that the estimated value of soil loss by wind erosion equation (W.E.Q.) for El-Bahariya depression is 104.87 t/ha/yr. Soil loss in this location is substantially severe and exceeds the tolerable level (11 t/ha/yr). Wind erosion led to a marked increase in coarse and very coarse sand percentages while decreased the percentage of F.S., silt, clay in the top surface. Wind erosion led to decrease the soil moisture retention and the available water for plant growth.

A considerable decrease in the soil organic matter content, total N, available P & K was observed. A guide line to the beneficial measures and practices that should be applied jointly to control and combat wind erosion hazards are suggested.

Key words: Climatic factor, wind erosion, soil physical, chemistry and fertility.

INTRODUCTION

Wind erosion climatic erosivity is a measure of the climatic tendency to produce conditions conductive to wind erosion. Wind erosion occurs when the shear stress exerted on the surface by the wind exceeds the ability of the surface materials to resist detachment and transport. Strong winds erode and dryness increases the susceptibility of the surface to erosion, Skidmore (1986).

Chepil et al. (1962) proposed a climatic factor to estimate average annual soil loss by wind for a range of climatic conditions. This factor, an index of wind erosion, is a function of soil moisture and average wind speed. The wind speed term was based on the rate of soil movement being proportional to the cube of average wind speed (Zingg, 1953).

The climatic factor as proposed by Chepil et al. (1962) was one of the five independent variables of the wind erosion equation which has been used widely during the past 20 years (Woodruff and Siddoway, 1965).

Arroug (1995) reported that erosion of soil by wind is markedly influenced by properties of soil physical, soil chemical and soil fertility.

The current study aims to estimate soil loss by wind erosion equation and its effect on soil physical, chemical and soil fertility for studied area.

Also, this research aims to evaluate the level of soil degradation, consequently soil desertification due to wind erosion and suggested the practical measures and practices to control and combat erosion and, in turn, to control soil desertification.

MATERIALS AND METHODS

This study was carried out during 2001 at El-Bahariya depression area in the central part of the western desert of Egypt. With latitudes between 27o 45 and 28o 30- N and longitudes 28o 30- and 29o 10- E. Total area is approximately 2250 km2.

This study intended to estimate the annual soil loss by wind erosion in this location, consequently the degree of soil degradation and probability of desertification and its control. By using the meteorological data, field measurements and soil analysis.

The eroded field in El-Bahariya depression location was divided into 25 plots, with an area of 600 m2/plot. To study the effect of wind erosion on soil properties for eroded field, surface soil samples (0-10 cm depth) were collected to represent the eroded field.

Soil erodibility factor (I) was estimated according to Carreker equation (1966).

Soil samples collected from the different plots for eroded field were analysed according to the method of Richards (1954); Jackson (1960) and Black (1965).

RESULTS AND DISCUSSION

1. Climate:

The climatic conditions that prevail over the Bahariya depression are extremely arid as indicated in Table (1) which gives the meteorological data of the depression over the period from 1960 to 1980.

It is obvious from Table (1) that rainfall is nil. The period between December and February represents the relatively actual rainy months.

Temperature data indicate that the lower temperature records prevail from November to March, while the higher ones were recorded between April and October. Furthermore, the lowest temperature values were recorded in January, whereas the highest ones were recorded in July.

Table (1): Meteorological data of the Bahariya depression (Average of 20 years, 1960-1980).

Month	Temperature (°C)			Rainfall (mm)	Relative humidity(%)	Average Evaporation (mm/day)	Surface wind Velocity m/sec	Water vapour pressure mbar
	Max.	Min.	Mean					
Jan	19.94	5.38	12.41	0.51	49.0	5.29	3.83	5.28
Feb.	22.57	6.69	14.63	0.67	41.5	6.98	4.63	5.00
March	24.26	9.33	17.99	0.22	34	9.28	5.31	5.20
April	30.18	13.57	21.89	0.33	29.5	11.06	5.90	5.70
May	34.45	17.63	26.21	0.2	28	13.52	5.65	6.74
June	36.38	19.64	28.88	0.1	31	14.1	5.89	8.64
July	37.01	21.04	29.46	-	35	13.5	5.65	10.30
Aug.	36.58	16.58	29.16	-	37	12.1	5.40	11.11
Sep.	34.58	19.35	27.07	-	42	10.58	5.22	10.72
Oct.	31.65	16.21	23.52	0.2	44	8.55	4.47	9.43
Nov.	25.47	11.04	17.81	0.4	51.5	6.33	3.93	7.84
Dec.	21.18	6.58	13.77	0.9	50.5	4.8	3.65	6.04
Annual mean	**29.64**	**13.93**	**21.78**	**3.53**	**39.4**	**9.63**	**4.93**	**7.69**

Evaporation data, as shown in Table (1), indicate that the lowest values, 4.8 mm per day, were recorded in December, while the highest (14.1 mm per day) were recorded in June.

Monthly variations in relative humidity, show a wide variation from 28% in May to 51% in November with an annual mean of 39.4%.

Surface wind velocity varies within narrow range, having an annual mean of 4.93 m/sec.

To characterize and define the prevailing climate of the Bahariya depression, the indices of Dokuckeav (1900), Lang (1920), Mayer (1926) and Emberger (1939) are applied. The results obtained reveal that the area under consideration lie under extremely arid condition or under desertic climatic type

2. Estimation of the annual soil loss by wind in El-Bahariya depression:

The annual soil loss via wind erosion in El-Bahariya depression location has been estimated using the wind erosion predication equation (W.E.P.E.) of Woodruff and Siddoway (1965) and the method described by Morgan (1995).

The basic equation is:

$$E = F(I', K', C', L', V)$$

Where:

E = Predicted annual soil loss, mt/ha/year.
I' = Soil erodibility factor, mt/ha/year.
K' = Soil roughness factor, dimensionless.
C' = Climatic factor, dimensionless.
L' =Width of eroded field by wind, m.
V = Vegetation cover factor, kg/ha.

The prediction of soil loss by wind erosion in El-Bahariya depression area was estimated using the meteorological data, field measurements and soil analysis as follows:

<u>2-1 Estimating soil erodibility index (I):</u>

Due to the sandy nature of the El-Bahariya depression soils, the equation developed by Carreker (1966) was found to be more convenient under the conditions of this study. This equation simply relates the percentage of coarse and very coarse sand (X) to soil erodibility (I) as follows:

$$I = 174 - 4.64\,X + 0.03X^2$$

Table (2): Calculation of soil erodibility factor (I) according to Carreker equation (1966) for El-Bahariya Depression.

Plot No.	Depth (cm)	C. S + V C.S.	Soil erodibility factor (I)
1	0 – 10	18.0	80.76
2	0 – 10	27.0	26.85
3	0 – 10	49.0	125.39
4	0 – 10	42.2	75.24
5	0 – 10	51.7	146.08
6	0 – 10	27.0	26.85
7	0 – 10	37.0	38.75
8	0 – 10	51.1	141.44
9	0 – 10	43.2	82.44
10	0 – 10	38.2	47.03
11	0 – 10	63.6	242.45
12	0 – 10	77.2	363.01
13	0 – 10	46.5	106.63
14	0 – 10	36.0	31.92
15	0 – 10	27.4	24.34
16	0 – 10	37.5	42.19
17	0 – 10	84.4	431.32
18	0 – 10	48.1	119.99
19	0 – 10	19.1	74.44
20	0 – 10	47.6	114.83
21	0 – 10	61.9	228.17
22	0 – 10	39.0	52.59
23	0 – 10	59.0	204.19
24	0 – 10	51.0	140.67
25	0 – 10	46.6	107.370
Mean			**122.99**

The calculated values of soil erodibility factor for El-Bahariya depression area are presented in Table (2).

It is obvious that the average value of soil erodibility factor is 122.99 mt/ha/year (E1).

2-2 Estimating climatic index (C) :

The index takes account of erosion by wind as a function of wind velocity and soil moisture content. The former is expressed by mean annual wind velocity (V, m/s) measured at a height of 9 m and the latter by the Thornthwaite precipitation effectiveness (P-E) index, thus

$$C = \frac{100}{2.9} X \frac{V^3}{(P-E)^2}$$

Where. P is the precipitation in mm, and E is mean evaporation in mm. Climatic index was calculated using the climatological characteristics for El-Bahariya depression, Table (1), where;

$$C = \frac{100}{2.9} X \frac{(4.93)^3}{(3.53-9.63)^2} = 111.04$$

2-3- Estimating ridge roughness index (K):

The roughness of ridges produced by tillage and planting equipment which is expressed by roughness factor (R) and calculated from:

$$R = 4H^2/I$$

Where; H is the ridge height and I is the distance between the ridges.

Values of K are expressed by:

K = 1 R < 2.27
K = 1.125 – 0.153 LnR 2.27<R < 89
K = 0.336 exp. (0.00324 R) R ≥ 89

For El-Bahariya depression area; ridge height was measured as 20.27<R<89 cm and spacing among ridges was 20 cm thus, R value is calculated as:

$$R = \frac{4X(1.5)^2}{20} = 0.45$$

Where; R < 2.7
K = 1

2-4 Estimating length of open wind blow (L):

The value of L is calculated as a function of equivalent field length (D) and the distance sheltered by any tress, shelter-belts, field hedges or windbreaks. The equivalent field length is calculated from measurements of actual field length (L, m) field width (W.m), field orientation expressed as the clockwise angle between field length and north (Φ ; rad), and wind direction clockwise from north (θ; rad):

$$D = \frac{LW}{LI(\cos(\pi/2 - \Phi)I + WI\sin(\pi/2 + \theta - \Phi)}$$

The value of L is then determined from L = D-10 H

Where, H is the height of the shelterblet.

For El-Bahariya depression area; the actual field length (L, m) was measured as 150.0 m, field width (w, m) was 100 m, Φ Rad = 30o and θ Rad = 45o, thus, D value is calculated as:

$$D = \frac{150X100}{150/Cos(22/14 + 45 - 30)/ + 100/\sin(22/14 + 45 - 30)/}$$

L = D – 10 H

L = 149.86

Where; H = zero in this study because there are not shelter belt.

2-5-Estimating vegetation cover (V):

The vegetation cover index depends on standing live biomass, standing dead residue and flattened crop residue.

As the estimated mass of the above ground standing vegetation stubble (R) for El-Bahariya depression field is equal 100 kg/h, it gives an effective equivalent flattened vegetation cover mass (V) of 500 kg/ha (Woodruff and Siddoway, 1965).

Applying the equation of Morgan (1995):

Step 1: $E_1 = I$

$= 122.99$

Step 2: $E_2 = E_1 \times K$

$= 122.99 \times 1$

$= 122.99$

Step 3: $E_3 = E_2 \times C$

$= 122.99 \times 1.11$

$= 136.52$

Step 4: $E_4 = (F^{0.3484} + E_3^{0.3484} - E_2^{0.3484})^{2.87}$

Where; F is the rate of soil detachment.

$F = E_2 [1 - 0.1218 (L/L_0)^{-0.3829} \exp(-3.33 L/L_0)]$

$L_0 = 1.56 \times 10^6 (E_2)^{-1.26} \exp(-0.00156 \times E_1)$

$L_0 = 2996.15$

$F = 122.99 [1-0.1218 (0.0501)^{-0.3829} - \exp(-3.33 \times 0.0501)]$

$F = 83.082$

$E_4 = [83.082)^{0.3484} + (136.52)^{0.3484} - (122.99)^{0.3484}]^{2.87}$

$E_4 = 93.57$

Step 5: $E_5 = gE_4^{h}$

Where; $g = 952.5^{(1-h)}$

Where, $h = \frac{1}{0.0537 + 0.9436 \exp(0.000112\ V)}$

$$h = \frac{1}{0.0537 + 0.9346 \exp(0.000112 X 500)}$$

h = 0.951
$g = 952.5^{(1-h)}$
$E_5 = (952.5)^{1-0.951} \times (93.57)^{0.951}$
$E_5 = 104.868$
Where; E_5 the estimated wind erosion-soil loss in El-Bahariya depression

Where; E_5 is the estimated wind erosion soil loss in El-Bahariya depression area. This increase in soil loss value is more attributed to the nature of particles and their size distribution in the soil surface, where the soil erodibility factor was 122.99 mt/h/year. Also, the influence of vegetation cover on soil loss by wind could widely vary according to the type and intensity of the prevailing climatic conditions. In this respect, most of the land surfaces are barren of vegetational cover due to the torric (dry) soil moisture regime and the role of vegetation in decrease soil loss by wind is negligible. These results are in agreement with reported by Lyles and Tatarko (1986) and Skidmore (1986)

According to Hudson (1981), soil losses from wind erosion less than 11 t/ha/yr is considered insignificant, but values as low a 2 t/ha/yr are recommended for particularly sensitive areas where soils are thin or highly erodible. Consequently, soil loss by wind erosion in El-Bahariya depression location is substantially severe and exceeds the tolerable level.

This high value in soil loss by wind in El-Bahariya depression lead to reduction in soil productivity where nutrients are concentrated close to the surface. Decreasing productivity led to high degradation (50 – 200 t/ha/yr), Dragne (1983), and consequently desrtification of this area. Accordingly, soil wind erosion in this location needs to be reduced and combated in a proper manner.

For wind erosion control, the aforementioned conservation practices will appreciably contribute to reduce soil loss by wind. by lowering of the factors I, K, L and V in the wind erosion prediction equation. Climate factor "C" may be greatly reduced by wind barriers to intercept the erosive wind energy.

3. Wind erosion effects on soil properties:

3.1. Wind erosion effects on soil texture and soil moisture retention:

The analytical data in Table (3) show that the texture is sand to loamy sand, changing to sandy clay loam in some samples. Gravel content varies widely, it ranges from 3 to 30% from the soil volume. This pattern of particle size distribution is mainly attributed to the removal of fine sand, silt and clay from the original soil surface throughout sorting by wind, where coarse sand is generally too large to be suspended and transported for a long distance by wind. These results are in agreement with those reported by Chepile (1957); Lyles and Tatarko (1986).

Soil moisture values are very low. Field capacity (0.1 atm.) for sandy-textured samples ranges from 2.81 to 5.24%, while wilting point values range from 1.91 to 3.65%. Therefore, the total available moisture is very low as it fluctuates between 0.9 and 1.59%. For loamy texture, the field capacity (0.33 atm.) ranges from 6.86 to 29.88%, whereas, the wilting point ranges from 3.48 to 13.88%. Thus, the total available moisture for loamy texture is relatively higher (3.38-16.0%) compared with sandy textured. The decrease of water retention and availability of the studied soil samples is mainly ascribed to the removal of fine fractions by the action of wind erosion and its impact on soil texture and pore size distribution. In other words, wind erosion led to an increase of coarse particles, bulk density and the drainable pores in the soil surface, thereby decreases the retention of soil moisture. This conclusion stand in agreement with those reported by Hajek et al. (1989), who stated that the erosion of soil led to degradation of soil texture and soil structure, therefore, decreases the amount of available water in soils.

3.2. Wind erosion effects on soil chemistry:

Data in Table (4) reveal that carbonate content ranges from 1.3 to 14.5%. Soil reaction in generally neutral to midly alkaline, as revealed by the pH values. Soil material is fairly free of salinity in some samples and is extremely saline in the others. The minimum record of salinity is 0.9 ds/m, whereas the maximum reaches 121 ms/cm. Salt composition shows that the predominant cations are Na and Ca, whereas, the predominant anions are Cl and SO4. Gypsum content is very low , not exceeding 2.83%

These data was in harmony with those reported by Arroug (1995) who stated that soil erosion markedly influenced the soil chemical

Table (3): Effect of wind erosion on some soil pjhysical properties for the studied location.

Plot No.	Gravel	V.C.S (%)	Mechanical analysis				Texture class	Moisture retention at The indicated suction (atm) by weight			
			CS (%)	FS (%)	Silt (%)	Clay %)		0.1	0.33	1.00	15
1	-	16	2.0	87	7.5	3.5	S.	9.48	6.95	4.40	3.30
2	-	16	11	78	7.0	4.0	S.	9.38	6.92	4.95	2.90
3	-	36	16.2	35.5	25.3	23.0	Scl	33.20	26.08	15.2	10.64
4	-	36	15.7	55.1	70.8	21.4	Scl	30.50	24.5	16.50	13.60
5	-	17	10.0	78.7	8.0	3.3	S.	9.77	7.00	4.38	3.52
6	-	16	21.3	68.3	6.0	5.4	S	9.00	7.30	4.5	2.90
7	10.0	16	35.1	58.9	3.5	2.5	S.	7.82	5.92	4.21	2.15
8	-	38	5.2	53.9	10.9	30.0	Scl	30.20	22.95	15.00	9.06
9	-	28	10.2	63.3	18.3	8.2	Sl	20.20	15.41	10.5	6.29
10	3.0	45	18.6	37.9	1.1	42.4	Sc	35.12	29.88	18.5	13.88
11	30.0	23	77.2	11.2	3.0	8.6	Ls	9.77	6.86	4.51	3.48
12	-	19	27.5	64.5	5.0	3.0	S.	8.22	5.82	4.10	2.7
13	10.0	17	19.0	71.2	5.6	4.0	S.	9.21	6.94	4.00	3.09
14	-	16	11.4	84.7	3.0	0.9	S	9.20	6.50	3.95	2.5
15	-	17	20.5	67.8	8.0	3.7	S	9.44	6.32	4.42	3.36
16	15.0	23	61.4	27.5	4.5	6.6	Ls	10.42	8.11	6.23	4.61
17	-	17	31.1	58.9	5.5	4.5	S.	7.81	5.21	3.23	2.51
18	-	29	18.6	58.0	7.5	15.8	Si	20.20	14.51	8.5	5.91
19	-	28	43.9	29.2	19.0	7.9	Sl	19.5	12.80	8.2	5.18
20	15.0	18	21	69.0	5.7	4.3	S	9.82	7.14	5.24	3.65
21	-	15	44	56	-	-	S	4.61	3.21	2.81	1.91
22	-	23	28.0	54.0	8.2	9.8	Ls	11.71	7.23	5.62	4.52
23	10.0	28	18.6	58.0	7.5	15.8	Sl	16.80	14.52	8.52	5.88
24	3.0	24	26.4	58.7	3.4	11.5	Ls	10.98	6.98	5.06	4.12
25	-	16	15.0	83.0	1.3	0.7	S	6.25	4.82	3.42	2.26

properties, particularly salinity, soluble cations and anions, CEC and exchangeable cations and also micronutrients content.

3.3. Wind erosion effects on soil fertility:

Data in Table (5) show that soluble P is generally less than 1.4 ppm, indicating a low fertility level for investigated soil samples. On the contrary, soluble K values are usually high as revealed from its values which range between 234 to 985 ppm.

Organic matter and total nitrogen varies considerably from 0.091% to 0.143% and from 49 to 75 ppm, respectively indicating the prevailing arid climate. Consequently, C/N ratio seem very low and fluctuates in a narrow range between 8.1 and 11.4. The decrease of O.M. and N.P.K for the studied soil samples due to wind erosion action could be ascribed to the removal of the particles and aggregates finer than 50-100 um in diameter. Due to this sorting, the soil texture of surface layer becomes coarser and organic matter content decreases over time, with potentially detrimental effects on soil structure, nutrient availability, cation exchange and water holding capacity. This conclusion is in harmony with those reported by Lyles and Tatarko (1986) and Zabeck and Fryrear (1986) who stated that wind erosion results in direct nutrient removal with eroded material and may change nutrient availability and decrease soil fertility.

Table (4). Effect of wind erosion on soil chemistry in El-Bahariya depression.

Plot No.	$CaCO_3$ (%)	pH (Paste)	EC dS/m	Saturation extract								$CaSO_4$ (%)
				Cations (me/L.)				Anions (me/L.)				
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	
1	1.4	7.0	5.6	24.8	6.4	36.0	1.2	-	2.3	42.0	23.0	Nil
2	14.5	7.6	17.90	36.0	24.0	160.0	1.7	-	2.3	179.0	41.0	Nil
3	3.1	7.0	121.0	125.0	59.0	1033.0	35.0	-	2.0	1156.0	96.0	2.83
4	6.5	7.0	117.0	92.0	41.0	1190.0	12.5	-	1.5	1228.0	107.0	2.1
5	9.9	7.8	22.40	40	28.0	200.0	4.2	-	2.5	217.0	51.0	1.44
6	6.5	7.2	5.72	25.1	9.5	30.0	1.1	-	1.8	35.0	28.2	0.6
7	13.0	7.6	3.90	19.7	3.4	21.5	0.7	-	3.7	30.2	9.1	Nil
8	4.5	7.2	113.4	120.0	89.0	1051.0	9.6	-	2.0	1165.0	96.0	1.54
9	9.0	7.5	16.00	37.0	32	101.0	2.3	-	1.5	127.0	43.0	1.17
10	6.0	7.4	51.1	66.0	81.0	424.0	1.8	-	1.5	500.0	71.0	2.42
11	9.0	7.6	47.4	52.0	32.0	440.0	20.6	-	1.7	458.0	66.0	1.92
12	9.0	8.1	0.9	3.4	1.6	3.5	0.5	-	2.8	4.7	1.5	0.1
13	11.2	7.6	8.90	32.0	18.0	56.0	1.4	-	2.5	70.0	34.0	1.75
14	9.0	7.5	117.7	92.0	64.0	1044.0	11.6	-	2.3	1128.0	84.0	1.76
15	9.0	7.6	33.6	51.0	26.0	306.0	9.3	-	2.6	233.0	60.0	1.42
16	15.0	7.2	26.2	50.0	35.0	195.0	2.1	-	1.7	234.0	46.0	1.17
17	1.4	7.8	13.0	36.0	12.0	111.0	1.1	-	2.2	110.0	40.0	1.46
18	8.3	7.9	66.7	68.0	41.0	69.0	8.6	-	1.5	637.0	81.0	2.3
19	9.6	6.9	118.9	95.0	69.0	1054.0	20.2	-	1.2	1113.0	124.0	0.6
20	10.0	7.7	6.6	20.8	7.2	47.7	0.8	-	2.4	48.0	28.0	Nil
21	1.3	7.4	41.0	130.0	66.0	240.0	9.0	-	21.0	340.0	95.0	1.4
22	3.4	7.8	6.0	16.0	13.0	41.0	6.0	-	5.0	46.0	25.0	2.61
23	9.5	6.9	89.0	132.0	363.0	739.0	36.0	-	12.0	1170.0	88.0	1.77
24	10.7	8.0	14.0	30.0	36.0	120.0	2.0	-	14.0	150.0	35.0	1.41
25	10.9	8.0	3.4	10.3	8.2	17.9	0.8	-	1.6	25.7	10.1	0.8

Table (5): Effect of wind erosion on soil fertility for El-Bahariya depression.

Plot No.	Depth (cm)	O.M (%)	Total N (ppm)	C/N	Available P (ppm)	Available K (ppm)
1	0 - 10	0.104	65.0	9.3	0.63	241
2	0 - 10	0.114	70.0	9.4	0.67	253
3	0 - 10	0.104	65.0	9.3	0.1	877
4	0 - 10	0.091	60.0	8.8	0.4	409
5	0 - 10	0.112	70.0	9.3	0.4	604
6	0 - 10	0.109	65.0	9.7	1.25	253.5
7	0 - 10	0.091	65.0	8.1	0.6	429
8	0 - 10	0.091	65.0	8.1	0.25	487
9	0 - 10	0.091	65.0	8.1	0.75	985
10	0 - 10	0.121	65.0	10.8	0.1	624
11	0 - 10	0.114	65.0	10.2	0.25	409
12	0 - 10	0.143	81.0	10.2	1.4	234
13	0 - 10	0.091	49.0	10.8	0.4	585
14	0 - 10	0.098	50.0	11.4	1.0	254
15	0 - 10	0.114	68.0	9.7	0.3	819
16	0 - 10	0.104	65.0	9.3	0.3	585
17	0 - 10	0.098	60.0	9.5	0.25	390
18	0 - 10	0.131	70.0	10.9	0.45	605
19	0 - 10	0.104	70.0	8.6	0.6	885
20	0 - 10	0.95	60.0	9.2	0.10	370
21	0 - 10	0.097	61.0	9.2	0.15	390
22	0 - 10	0.114	70.0	9.4	0.7	925
23	0 - 10	0.104	65.0	9.3	0.9	975
24	0 - 10	0.114	75.0	8.8	0.3	388
25	0 - 10	0.098	65.0	8.7	0.19	452

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الأرصاد الزراعية وعلاقتها باحتمالات التصحر في منخفض البحرية - الصحراء الغربية - مصر

جمال عبد الرحمن ضاحي
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تعتبر عملية التصحر أحد الظواهر الطبيعية التي تعانى منها المناطق الجافة وشبة الجافة في العالم بصفة عامة في الصحراء الغربية-مصر بصفة خاصة.

لذلك أجريت هذه الدراسة بهدف:

١. تقيم درجة التصحر في منخفض البحرية بالصحراء الغربية -مصر والناتج عن عملية الانجراف بفعل الرياح وذلك بتقدير فاقد التربة بالانجراف بالرياح باستخدام المعادلة العامة للانجراف بالرياح (W.E.Q) والتي اقترحها Woodruff and Siddoway (1965) وكذلك طريقة Morgan (1995)

٢. دراسة بعض الخواص الفيزيائية والكيميائية والخصوبية للطبقة السطحية(صفر_١٠)سم لمنطقة الانجراف eroded area وتأثرها بعملية الانجراف بالرياح.

- ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي:

١. وجد أن فاقد التربة بالانجراف بالرياح كان ١٠٤,٨٧ طن/هكتار/سنة في منخفض البحرية بالصحراء الغربية مصر ويتضح من ذلك أن كمية التربة المفقودة بفعل الرياح تعتبر كبيرة جدا وتزيد عن معدلات الفقد المسموح بها وهى(٢-١١طن/هكتار/سنة)

٢. وبالتالي فان درجة التدهور في هذه المنطقة تقع في النطاق العالي حسب التقسيم الدولي حيث يكون فاقد التربة بالانجراف من(٥٠-٢٠٠طن/هكتار/سنة)

٣. أدت عملية تدهور التربة بفعل الانجراف بالرياح إلى زيادة نسبة الرمل الخشن في الطبقة السطحية وانخفاض نسبة كل من السلت والطين

٤. أدت عملية الانجراف بالرياح إلى خفض النسبة المؤية للرطوبة بالتربة عند الضغوط المختلفة وكذلك خفض نسبة الماء الميسر للنبات في الطبقة السطحية للتربة بمنطقة الدراسة.

٥. أدت عملية تدهور التربة بفعل الانجراف بالرياح إلى خفض نسبة كلا من المادة العضوية والنيتروجين الكلى والفوسفور والبوتاسيوم الميسرين في الطبقة السطحية لمنطقة الدراسة.

وعلى ذلك يجب استخدام وسائل ونظم التحكم المناسبة في عملية الانجراف بالرياح لتقليل فقد التربة وتدهورها في منخفض البحرية -- الصحراء الغربية -- مصر.

Sand Dune Movement and Its Effect on Cultivated Lands in Africa: Case Study: Dakhla Oasis, Western Desert, Egypt

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ABSTRACT

Desertification is one of the most serious problems in Africa. Most of the drylands in Africa are moderately or severely affected by desertification. Sand dune movement has threatened cultivated lands, irrigated channels, houses, and artesian wells of the Egyptian oases, especially Dakhla. Sand dunes in Dakhla are represented by two main types, crescentic and linear dunes. Gedida, Qalamun, Mushiya, and Ezab El-Qasr settlements are the main villages that suffer from the migration of sand dunes in Dakhla oasis. The rate of movement of the Dakhla dunes was measured using two sets of aerial photographs, 1961 and 1982. The rate of crescentic dune movement ranges from 0.5 to 14.0 m/yr with an average of 5.8 m/yr. Liner dune movement averages 7.5 m/yr. The most important factors controlling dune movement are dune size and local wind velocity. In general small dunes move faster than the bigger ones. The average rates of growth for the dune widths and lengths are 25 to 37 cm/yr, respectively.

Sand drift potential (DP) formula of Fryberger (1979) was used on the average effective wind speed categories at Dakhla and Farafra oases. The months of spring season showed the highest resultant drift potential. Stabilization of moving dunes in Dakhla is very difficult and expensive.

INTRODUCTION

Land is the critical resource and the basis for survival for most people in Africa. Agriculture contributes about 40% of regional GDP and employs more than 60% of the labor force (World Bank 1998). Sand dune movement takes place in dry land areas where fragile lands, nil rainfall and harsh climate. The result is the reduction of cultivated lands followed by loss of the land's ability to sustain crops, livestock or human activity. The productivity of some lands has declined by 50% due to soil erosion and desertification. Yield reduction in Africa due to past soil erosion may range from 2 to 40%, with a mean loss of 8.2% for the continent (Eswaran et al., 2001). About 60% of the African

continent is classified as arid lands (Lancaster, 1996), which include the Earth's most extensive desert region, the Sahara, as well as the Kalahari and Namib deserts. The present study deals with movement sand dunes in the Dakhla oasis, Western Desert, Egypt, as a case study for the African dunes. Dakhla oasis lies in the southern part of the Western desert of Egypt (Fig. 1). Transportation of sands by wind has been investigated by several authors. The fundamental works are those of Bagnold (1941) and Fryberger (1979) who developed mathematical equations to calculate the rate of sand drift. Ashri (1973) measured the movement rate for 92 crescentic dunes in Kharga oasis by comparing two sets of aerial photographs, 1944 and 1961. The measured rate was 12 m/yr. The rate of dune movement in Kharga was also measured in 1979 using two sets of topographic maps (1:25,000), 1930 and 1961 for Kharga and Dakhla oases. The average rate was 9 and 5.5 m/yr for Kharga and Dakhla oases, respectively (Embabi, 1979). Field measurements for one year indicated that dune movement varies between 20.8 and 100 m/yr. (Embabi, 1981). Two sets of aerial photographs, 1961 (scale 1:50,000) and 1982 (scale 1:60,000) were used to calculate the annual rate of dune movement. A suite of 82 crescentic and 25 linear dunes were selected for measuring the dune movement. The studied dunes were selected to represent the various belts, dune forms, and sizes. Prominent topographic features were used as land marks. The width and length of crescentic dunes and their distance from the toe of slipface to the nearest suitable land mark, were measured using stereoscopic caliper to an accuracy of 0.1 mm that represents ground distance of 5 and 6 m for the aerial photographs of the 1961- and 1982-flights, respectively. The small dunes ranging from 3 to 17 m could not be accurately measured from the present aerial photographs. The annual rate of dune movement was computed using the rate of sand drift potential equation of

Fryberger (1979) for Dakhla and Farafra sands.

Sand dunes in Africa

Sand dunes cover about 18% of the African deserts, Sahara, Kalahari and Namib. Linear and crescentic dunes are the main types in Africa.

Sahara dunes: Sahara is the world's largest desert and covers about 7 million km^2 (Lancaster, 1996). It forms about 86% of the African deserts. It is a region of high temperature and violent winds. Drifting sands occupy only about 20% of the Sahara surface area and form some of the world's largest sand seas. The sand-transport pathways reflect

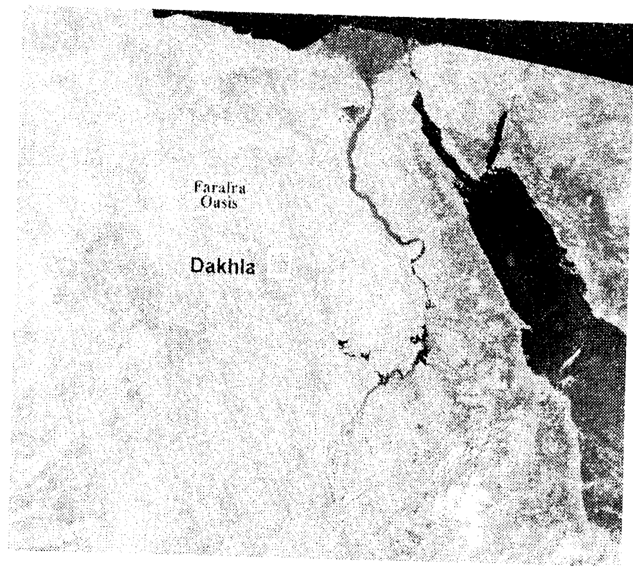


Figure 1. Landsat image of Egypt showing locations of Dakhla and Farafra oases, NASA.

the dominance of the trade-wind circulation, north-south and northeast-southwest (Fig. 2). The average rate of dune movement ranges from 5 to 15 m depending on the dune height (Beadnell, 1910, Embabi, 1981 and 1982, Haynes, 1989, Philip et al., 1992), the smaller the dunes the faster movement. Linear and crescentic dunes are the main dune types in the Sahara, which form sand seas. Star dunes occupy smaller areas within the sand seas especially in Algeria and Libya (Breed et al., 1979).

Kalahari dunes: The Kalahari Desert is part of an extensive sand-covered plain at an elevation of 800-1200 m (Lancaster, 1996). Linear dunes are the most dominant dune types (Fig. 3). In recent geologic history, 10,000 to 20,000 years ago, the Kalahari dunes were stabilized by vegetation. Unlike the dunes of the Sahara Desert, those of Kalahari are stable and not wandering.

Namib dunes: The Namib Desert is a coastal desert that is characterized by two parallel patterns of crescentic and linear dunes along the Atlantic coast (Fig. 4). Namib dunes are the oldest in the world (approximately 30 million years old) and spread over 32,500 km^2 (300 km along the coast and 140 km into the inland). Dunes grow about 20 meters a year (Namibweb.com, 2002). Star dunes occur inland and they are considerably less active than the coastal crescentic dunes due to decreasing wind energy from the coast (Breed et al., 1979).

Sand dunes in Dakhla oasis

Physical environment: Dakhla oasis lies between latitudes 25 and 26°N, and longitudes 28 and 30°E. It is located in the hyperarid core of the eastern Sahara, far from the maritime

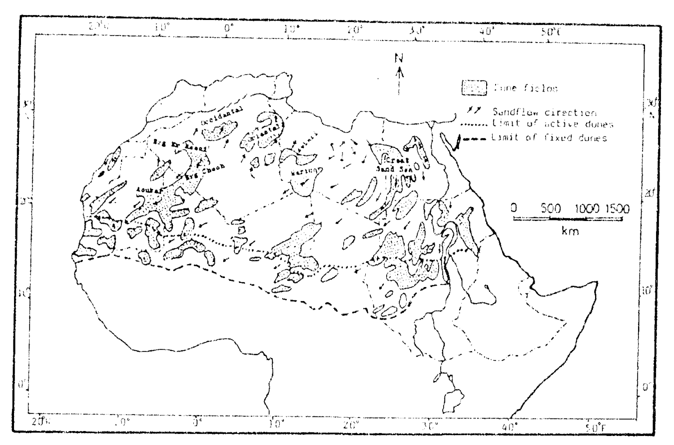


Figure 2. Distribution of sand dunes in the Sahara desert (after Williams, 1984)

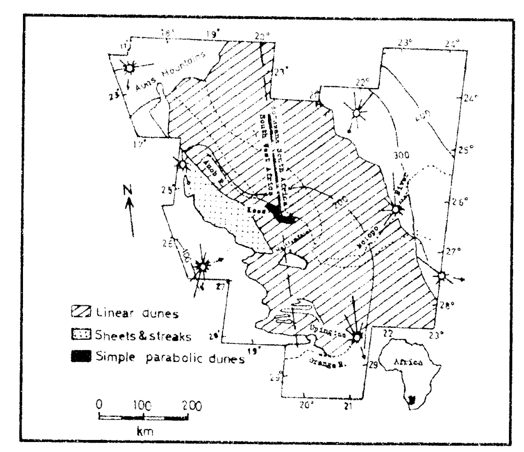


Figure 3. Distribution of sand dunes in the western Kalahari desert (after Breed et al., 1979)

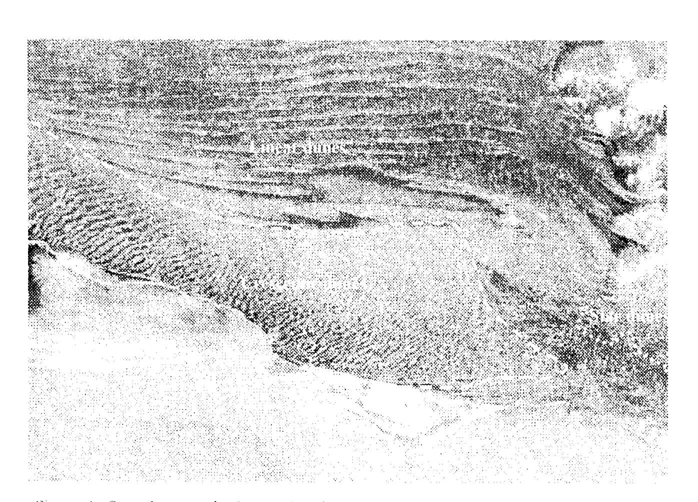


Figure 4. Spaceborne radar image showing part of the vast Namib Sand Sea on the west coast of southern Africa, which has parallel dune zones. This image was acquired by Spaceborne Imaging Radar-C/X-Band Synthetic Aperture Radar (SIR-C/X-SAR) onboard the space shuttle Endeavour, 1994. It is 54.2 kilometers by 82.2 kilometers. NASA

influence of the Mediterranean, Atlantic, and Indian oceans. Rain, in the form of light showers rarely falls during winter. The annual mean rainfall is practically zero, while the maximum is 8 mm recorded in one day, February 1942. Mean annual evaporation is 16.4 mm/day. June is the month of maximum evaporation (24.8 mm/day). Mean monthly temperature ranges from 12°C in January to 30.9°C in July, with an annual mean of 29°C. The prevailing wind direction is NNW (Fig. 5), but some aeolian features such as sand dunes and clay hammocks in the northern part of the oasis show deflection of the wind to NNE due to the influence of the northern plateau (Sharaky, 1990). Winds of gale force and above are infrequent in Dakhla oasis

The annual mean of surface wind speed larger than 10 knots is about 13%.

Topography: Dakhla oasis forms a depression that is bound on its northern side by a precipitous escarpment running in a general WNW direction for a distance of about 250 km (Said, 1962). Land surface of the depression floor slopes gently to the NE.

Geology: Five rock units represent the formation of Dakhla depression (Said, 1962). They are, from top to bottom: Chalk, Dakhla Shale, Phosphate beds, Variegated Shale and Nubian Sandstone that exposed on the Dakhla floor and extends southwards to form a gently rising desert. Formation of Dakhla depression is discussed by Beadnell (1901) and Hermina et al., 1961, who suggested the possibility of erosion during Oligo-Miocene times.

Distribution of sand dunes

Sand dunes in Dakhla cover about 600 km^2. They are extensive in the western part of the depression, west of 29° E Sand dunes are arranged in five parallel dune belts perpendicular to the longitudinal axis of the depression (Fig 6). Unlike the whole system of northeast Africa, the dune patterns in Dakhla moves counter clockwise around a point near Gebel Abu Tartour (29° 43' E and 25° 33' N).

Types of sand dunes

Sand dunes in the Dakhla depression are represented by two main types, crescentic and linear dunes. Compound crescentic dunes (barchanoid ridges) are the most common type in the Dakhla depression. Linear dunes mainly occur in the southern segment of the eastern dune belt. Type and distribution of Dakhla dunes are mainly controlled by directional variability of wind regime, wind speed, distance from the northern plateau, space between dunes and local topography.

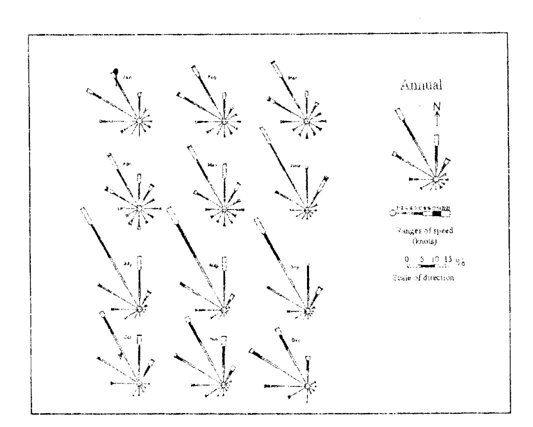


Figure 5. Wind roses at Dakhla Oasis, 1971-1980 (Sharaky, 1990).

Movement of sand dunes

Two series of aerial photographs covering the western half of the Dakhla depression (21 years apart) were employed in the preset study for determining dune movement. A suite of 82 crescentic and 25 linear dunes were selected for measuring the dune movement. The studied dunes were selected to represent the various dune belts, forms, and size. The width and length of crescentic dunes and their distance from the toe of slipface to the nearest suitable land mark were measured. The rate of Dakhla crescentic dune movement ranges from 0.5 to 14 m/yr with an average of 5.8 m/yr (Table 1). The movement varies from one site to another depending on local conditions. The most important controlling factors are dune size and local wind velocity. Small crescentic dunes move faster than the larger ones. Northern dunes are smaller in size and mover faster than the large southern dunes. The average rate of crescentic dune growth in width and length are 25 and 37 cm/yr.

Sand drift potential (SDP)

Sand drift potential formula of Fryberger (1979) was applied in the present study using the average effective wind speed measured by Dakhla and Farafra meteorological stations (1970-1980). The values representing the relative rates at which winds of different average velocities can move sands, are called weighting factors (Fryberger, 1979). These are derived by substituting values of wind velocities (average wind speed of a velocity category) for the weighting formula of Lettau (1975; in McKee, 1979, p.146) as follows:

$q = V^2\ (V - V_t)$, where q = rate of sand drift potential, V = wind velocity at 10 m height and V_t = impact threshold velocity.

Fryberger (1979) classified energy of surface winds at arid regions, based on the average annual drift potential, into three groups: (1) low-energy environment with drift potential (DP) less than 200 vector units (VU), (2) intermediate-energy wind environment with DP ranges from 200 to 399 VU; and (3) high-energy wind environment with DP greater than 400 VU. The threshold velocity of 0.2 to 0.3 mm quartz sand grains was estimated as 11.6 knots for many desert dune sands (Fryberger, 1979). This value was rounded to 12 knots and used in this study. The average value of the annual drift potential at Farafra oasis (1882 VU) is much higher than that at Dakhla oasis (787 VU). According to the energy classification of surface winds at arid regions (Fryberger, 1979), both Dakhla and Farafra regions belong to the group of high energy wind environments.

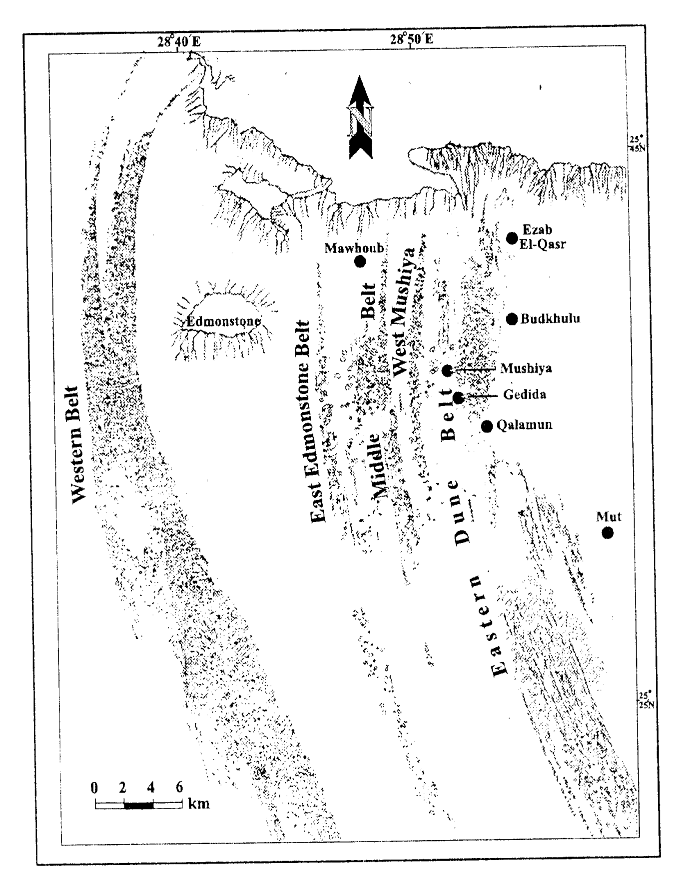


Figure 6. Types, distribution and threatening of sand dune belts in Dakhla Oasis. From uncontrolled mosaic aerial photos of 1961 flight.

Table 1 Annual rate of movement and dimensions of Dakhla crescentic dunes

No.	1961-flight		1982-flight		Rate
	Width	Length	Width	Length	m/yr
Western dune belt					
1	125	77	126	90	9.8
2	80	50	84	54	11.8
3	165	107	174	114	6.9
4	140	87	156	99	5.3
5	140	65	156	93	7.6
6	150	85	135	102	6.1
7	112	87	87	75	10.2
8	175	102	165	105	4.9
9	127	100	135	84	8.6
10	95	67	90	51	13.6
11	127	67	123	69	9.3
12	67	67	72	70	9.8
13	115	102	123	120	7.4
14	110	82	114	122	7.2
15	142	100	141	100	6.4
16	155	140	165	153	5.7
17	100	75	114	84	6.9
18	150	127	150	135	5.5
19	155	100	168	105	5.4
20	50	60	51	60	7.9
21	150	100	160	102	4.2
22	150	100	144	120	7.6
23	177	100	180	96	7.3
24	195	125	190	126	2.9
25	255	150	246	150	2.8
26	240	160	252	168	2.0
27	250	150	270	150	5.7
28	325	140	348	150	5.3
29	120	75	126	78	8.9
30	300	110	288	126	1.2
31	150	105	147	120	3.0
32	260	165	294	162	1.5
33	200	115	204	126	1.2
34	80	75	81	78	2.7
35	275	105	300	114	1.1
36	250	175	260	180	0.5
East Edmonstone dune belt					
37	130	115	132	114	8.3
38	160	120	159	120	4.8
39	145	175	162	144	2.2
40	80	65	72	60	7.6
Middle dune belt					
41	215	150	180	156	4.2
42	165	120	144	132	7.7
43	450	445	400	400	2.6
44	325	270	360	306	3.1
45	200	190	228	222	2.5
46	225	190	240	174	3.4
47	182	132	192	129	6.5
West Mushiya dune belt					
48	265	177	220	156	6.8
49	220	150	222	189	5.4
50	155	252	162	204	3.1
51	200	276	171	228	3.9
52	205	300	276	208	2.6
53	285	315	294	342	3.5
Eastern dune belt					
54	95	85	96	81	9.8
55	85	60	90	63	11.1
56	105	85	96	93	11.6
57	225	215	220	210	2.4
58	275	250	288	270	7.1
59	115	120	111	150	3.8
60	100	115	126	114	6.4
61	100	125	108	132	5.1
62	200	205	216	222	1.7
63	135	190	156	186	3.0
64	100	140	102	156	3.7
65	115	125	126	144	5.3
66	117	172	129	162	5.1
67	105	150	120	168	4.5
68	150	165	156	234	6.1
69	35	55	-	-	13.8
70	95	105	96	120	5.7
71	60	110	62	120	5.9
72	85	120	90	126	8.2
73	165	150	156	180	3.3
74	100	155	105	114	1.5
75	80	125	84	102	3.4
76	87	100	48	60	7.9
77	200	170	190	171	5.1
78	145	165	135	165	6.7
79	105	100	109	106	4.3
80	185	127	189	162	5.1
81	185	212	180	216	5.2
82	145	145	150	150	5.5

Monthly and annually sand roses for the 12 directions were plotted for the sand drift potentials in both Dakhla and Farafra oases (Fig. 7). The arms of the sand rose are proportional in length to the sand drift potential values. Sand roses show that the DF varies greatly from one direction to another as well as from month to another according to the effective wind velocity. In general, the annual sand rose of the Dakhla oasis is wide-unimodal, where more than 90% of the DP fall within four adjacent directiocal categories from 285°-314° to 15°-44°. On the other hand, Farafra oasis is obtuse bimodal, where two mode directions form about 44% of DF in the directions 255°-284° and 15°-44°.

The net sand transport potential was measured from each sand rose using the Pythagorean theorem, which is referred to as the resultant drift potential (RDP) and expressed as vector units (Fryberger, 1979). Results show that April has the highest RDP of 91 and 298 VU at Dakhla and Farafra oases, respectively. The resultant drift potential direction at Dakhla oasis varies from SE in Jan.-Apr. to SSE in May and changes from SSE in June to south in July-Nov. then diverts again to SE in Dec. The annual RDP at Farafra oasis is relatively higher than that at Dakhla (Fig. 8). It is directed to SE (131°), the main direction of the Great Sand Sea. Thus the main source of Farafra dune sands is most probably the Great Sand Sea that lies at about 50 km west of the Farafra oasis. The annual RDP at Dakhla oasis (612 VU) is lower than that at Farafra oasis (968 VU). This denotes that the amount of sand reaching the Dakhla depression from Farafra is greater than that blown out to the Dakhla depression. This may explain the increase of the Dakhla dune size with time. The ratio of RDP/DP is used as an index of the directional variability of wind.

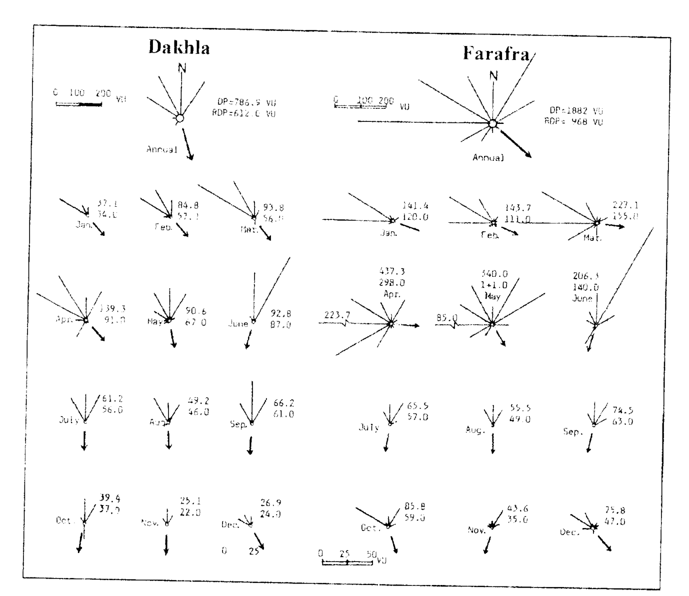


Figure 7 Sand roses of Dakhla and Farafra oases.

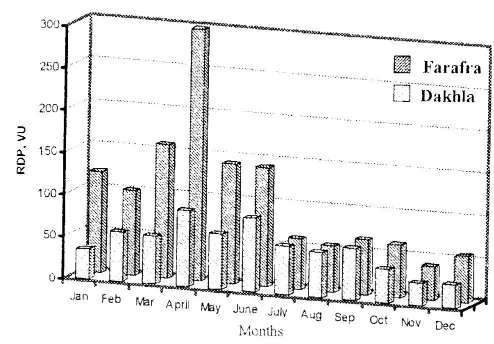


Figure 8 Monthly variations of resultant drift potential (RDP) at Dakhla and Farafra oases.

It approaches unity when wind blows from the same direction, and becomes closer to zero when wind blows from many directions. Fryberger (1979) classified wind variability into three classes: (1) low (less than 0.3), (2) intermediate (0.3 to less than 0.8), and (3) high (0.8 or greater). Results show that wind variability at Farafra is intermediate (0.5) while it is high at Dakhla (0.8).

Dune movement threat

Gedida, Qalamun, Mushiya, and Ezab El-Qasr are the main villages that suffer from migrating dunes in Dakhla (Fig. 6). The dunes attack cultivated lands (Figs. 9A, B and C), water wells and irrigating canals (Figs. 9C and D), roads (Fig. 9E) and houses (Fig. 9F).

The northern ends of Dakhla dune belts usually threat the Dakhla-Farafra highway after any wind storm. Some telephone poles have been lengthened several times. Moving dunes attack several roads in the Western Desert of Egypt as well as in Dakhla. The highways Kharga-Asyiut, Kharga-Dakhla, and Bahariya-Giza are facing sand dune encroachment.

Stabilization of moving dunes in Dakhla oasis is very difficult and expensive. Nevertheless, few trails for dune stabilization have been made. Fixation by vegetation to protect cultivated lands and houses is generally practiced in places where water is available. Sand fences were often built in Dakhla oasis using two horizontal reeds, about 50 cm apart, tied with vertical palm leaves by ropes. This primitive type of fence reaches one meter in height and is considered as a temporary method. In general, the protection against migrating dunes in Dakhla oasis as well as many desert regions is almost impossible. Thus the most economical method to deal with migrating dune belts is to get out of their way. However, to keep transport going, blown sand

covering roads is usually removed mechanically throughout the year.

Summary and conclusions:

The African continent consists of a gigantic plateau with shallow depressions. It has more than one third of the world's arid lands represented mainly by the Sahara, Kalahari, and Namib deserts. Dunes are the most distinctive aeolian feature of the African arid lands. They cover about one-fifth of the African deserts being extensive in the shallow depressions. Linear and crescentic dunes are the main dune types in Africa, but linear dunes are the most common. In Egypt, sand dunes cover more than 17% of the land surface. The Great Sand Sea constitutes about 80% of the Egyptian dunes.

Sand dunes of the Dakhla oasis are represented by two main types, crescentic and linear dunes. The compound crescentic dunes (barchanoid ridges) are the most common type. Linear dunes mainly occur in the southern part of the eastern dune belt. Dakhla dunes are in continuous motion southwards and threaten roads, houses, cultivated lands, irrigated channels and artesian wells. The Dakhla dune movements are mainly controlled by the directional variability of the wind regime, wind speed, distance from the northern plateau. The rate of Dakhla crescentic dune movement ranges from 0.5 to 14 meters per year with an average of 5.8 m/yr. The southern extremity of linear dunes southwest of Mut ranges from few meters to 15 m/yr with an average of 7.5 m/yr. The average rate of crescentic dune growth is 25 cm/yr for width and 37 cm/yr for length. Monthly sand roses showed that the drift potential (DP) varies greatly from one direction to another according to the effective wind velocity. The average annual DP at Dakhla is 787 VU, while it is 1882 VU at Farafra. Spring season showed the highest RDP. Stabilization of moving dunes in Dakhla is very difficult and expensive. Thus, the best way to overcome threatening dunes is to get out of their way.

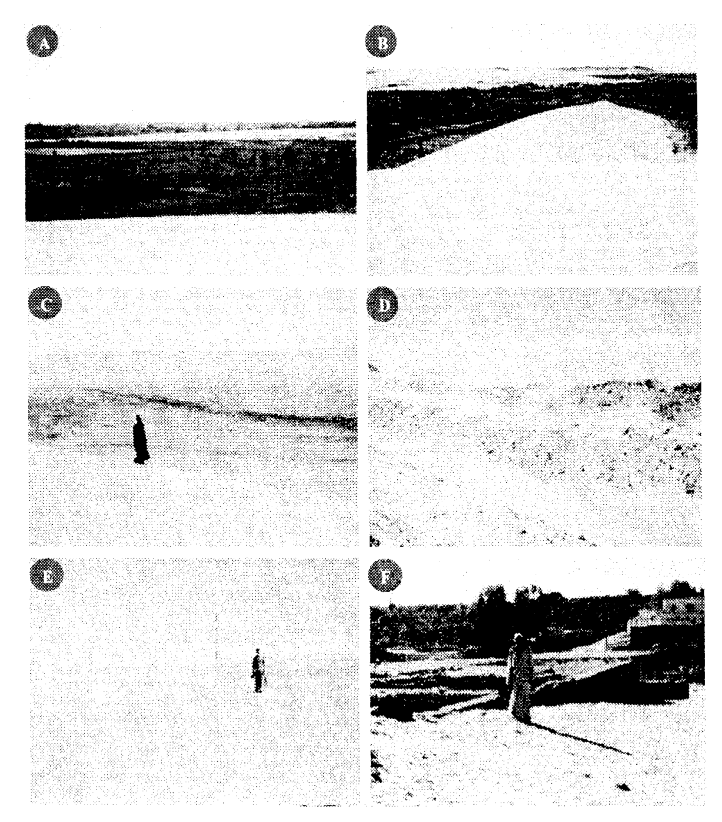


Figure 9. Sand dune movement threatening in Dakhla Oasis.
A. Cultivated land at Gedida.
B. Cultivated land at Mut.
C. Former cultivated land at Ezab El-Qasr.
D. Sand-buried irrigated channel at Ezab El-Qasr.
E. Dakhla-Farafra highway at Mawhoub.
F. Sand-buried houses at Mushiya.

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Technical session 5:

Drainage for Water Table and Salinity Control:

- *M.B.Abdel Ghany*

  "Hyraulic performance of subsurface drainage system implemented by trenchless machine".

  (Drainage Research Institute, National Water Res. Center).

- *A.s. El-Hassanin[1], M.B. Abdel Ghany[2] and M.A. Eissa[2].*

  "Drainage criteria of subsurface drainage of slightly-slopping lands in Arid African Regions".

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- *E.I.Gaber[1], M.B. Abdel Ghany[2] and F.I Morsy[2].*

  "Drainage performance in Nile Delta fringes of Egypt".

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- *M.M. Saied, S.M. El-Barbary, H.A. Shams., El-Din and M.S.M Abo soliman*

  " On Farm water management in rice field under conventional and modified drainage laterals concepts".

  (Soil Water and Environment Res. Inst., Agric. Res. Center).

- *M.S.M Abo soliman, E.A. Gazia, M.M.Said and M.A. Abou-El-Soud.*

  " Evaluation of Mole draine practices under heavy clay salt affected soils at North Delta".

  (Soil Water and Environment Res. Inst., Agric. Res. Center).

Hydraulic Performance of Subsurface Drainage System implemented by Trenchless Machine

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1. ABSTRACT

Field drainage in many countries has evolved in the last 20 years from a purely manual job into a highly mechanized operation. Techniques and skills are now being developed to reduce labour requirements and increase efficiency. Some of these activities are now close to being fully automated operations. The use of lightweight flexible plastic pipes and the introduction of trenchless techniques have had a considerable influence upon this development.

The most common types of machines, which are used in installing field drains, are trencher and trenchless machines. The plough-in method of drain installation has been termed "trenchless", in contrast to the "trenching" method, which involves both soil excavation and back-fill operations. The trenchless method places the tubing at a prescribed depth in an open space beneath a temporarily displaced column of soil.

The use of the trenchless machine (V-plow) in Egypt is considered a good alternative for the traditional trenching method. This installation technique was tested against the traditional trenching technique, in Haress area (8000 feddans), located about 25 km south of Alexandrea. The area soils are sandy loam soils. The area was split, by almost half, among the two installation techniques.

The hydraulic performance of the V-plow installed systems was compared against those installed by means of the trencher installation technique. Water table draw down curves were used as indicator of the hydraulic performance of the drainage systems.

The drainage system in the area was surveyed by means of Video Camera, while soil hydraulic conductivity was determined by means of the auger hole methods. The lateral of the systems was sorted by the installation date. The lateral exhibiting well Video inspection results were considered. Diversity hydraulic conductivity values were a factor in the choice of the systems as well.

The collected draw down curve was divided into three parts: rising head part, fast falling part (falling rate-1) and slow falling water table (falling rate-2). The most important factors, which affect the hydraulic performance of field drains, are the soil hydraulic conductivity, the irrigation quantity, and the installation method. The initial water table rise, one day after irrigation can be used as indicator for the irrigation quantity. It should be considered that, this could be used for quantities comparison, only in case of similar soil condition.

The study findings indicate that for the soil ranges and crops, included in the study, the hydraulic performance of the systems-installed by the trencher method is slightly better than those installed by the V-plow method.

2. INTRODUCTION

Drainage mechanization and the use of new drainage materials reduced installation costs and improved drainage efficiency. The introduction of mechanization in the pipe laying process, has lead to increasing productivity, reduction of the construction period, elimination of certain work processes (e.g. grading), and increasing the quality and improving the conditions of work for workers.

The most common types of machines, which are used in installing field drains, are trencher and trenchless machines. The plough-in method of drain installation has been termed "trenchless", in contrast to the "trenching" method, which involves both soil excavation and back-fill operations. The trenchless method places the tubing at a prescribed depth in an open space beneath a temporarily displaced column of soil. The lifting action causes a deformation and a disruption of the soil upward and towards both sides (Naarding, 1979).

Fouss,(1974) stated that most trenching machines in operation today for installing subsurface drainage pipes have been developed and modified according to the advice of contractor- users. Drainage contractors are innovative individuals, and have often provided the ideas behind machine design changes. Since the introduction and use of corrugated plastic pipes, several design changes have been made in trenching machines, which are as follows.

- Tube feeding and guiding devices;
- Grooving-devices for trench bottom;
- Automatic grade-control systems (LASER system)

Hawkins and Westland, (1989) stated that trenchers can be classified into, chain, wheel and trapezoidal. The first category is designed so that it has a long rotating chain that allows a vertical trench to be excavated, starting from 0.1 up to 0.2 meter. This machine can be used for either shallow or deep systems.

The trapezoidal excavator machine is a modified wheel type excavator that excavates the complete profile of a smaller canal. Even with an uneven pad surface, the digging portion of the excavator can take its grade from a present strangling that allows it to provide exact grade for the finished canal or drainage ditch using laser technology.

The characteristics of the common types of trencher machines are: (Naarding, 1979):

- Horsepower, the engine power ranges from 100 to 200 HP
- Depth and Trench Width: The excavation depth and trench width of the machine varies through interchanging digging attachments. The maximum depth of a trencher is somewhere between 1.0 m and 1.8 m. The trench width varies roughly between 0.12 and 0.20 m, while the standard width for field drains being 0.20 to 0.25 m. Therefore the trencher machines are able install lateral drains and collector drains.
- Weight: The weight of the machine varies between 10 and 23 tons for machine engine power of 100 and 250 HP, respectively. The pressure on the surface of these type of machines are about 0.25 to 0.35 kg/cm^2.
- Laying Capacity: The laying capacity of the chain trencher machine depends on drain depth, drain length, condition of the soil, topography and the engine power of the machine.

The laying capacity of a typical trencher machine is from 400 to 500 m/hour under favourable conditions. It may decreases to up to 300 m/hour under bad weather conditions (Naarding, 1979). Sometimes the capacity decreases when

the machine works in wet soil or sticky clay soil. However pouring some water over the knives can solve this problem. Cavelaars et al. (1994) mentioned that the operational speed of light drainage machines could reach up to 1000 m/hour. The net output depends on installation depth, soil type, and field conditions. Depending on machine models and pipe materials, different attachments are available for laying clay, concrete and plastic pipes.

Boels (1979) stated that the trenching drainage method involved both soil excavation and back-fill operations. They are suitable for use in most soil types. However, under very wet conditions, some chain type trenchers bring the soil into state of super saturation, resulting in such a soil consistency that the digging teeth become unable to remove the material from the trench. In Egypt, the installation quality in unstable soils (e.g. construction of Mit Kenana Pilot Area) has proven to be difficult with the traditional trenchers. The trenches tend to collapse immediately, causing an increased risk of pipe damages and envelope disturbances by falling soil chunks of the more heavy top soils (DRI, 1995a).

The techniques of trenchless drainage pipe lying developed from the idea of lining mole drains (Hawkins and Westland, 1989). The corrugated PVC pipe can be installed without any excavation. Cavelaars et al., (1994) stated that this technique has been used since 1965, after flexible corrugated plastic piping appeared. Trenchless machines have the potential to work faster than trenchers. A working speed of 2500 m/hour is possible with a drain depth of 1.0 m. However, the power requirement increases for larger depths of pipe installation, but soil type and conditions heavily influence the power requirement (Hawkins and Westland, 1989).

Winger, (1979) stated that there are two types of trenchless machines that are operating throughout the world. Both types are characterised with high speeds, and can install pipes up to 2.0 m deep. Both types perform satisfactorily only in the sandy, lighter textured soils, which are free of rocks and cemented materials. The development of the plough blades has been oriented towards both the chisel or vertical shaped blade and the Delta or V-plough (Zeijts and Naarding, 1990)

The V-Plough.

In 1962, the German, Willner modified the shape of the vertical plough in order to be V-shaped. The V-plough blade is designed to lift and split the soil as it moves forward, and the tubing is fed behind the plough before the soil falls back around the tubing. The V-plough is now fully established and used frequently, as is the chain trencher (Eggelsman, 1979).

The characteristics of the most common trenchless machines can be summarized as follows: (Naarding, 1979):

- Horsepower: The engine power of the trenchless machine with the V-plough ranges from 320 to 400 HP.

- Depth: The installation depth of the trenchless machine with V-plough varies between 1.2 and 1.8 m. This depth can only be reached when the soil surface is dry and the subsoil wet.
- Weight. The weight of the trenchless machine varies between 27 and 41 tons according to machine engine power of 320 and 400 HP respectively. The pressure on the surface of these type of machine are about 0.46 to 0.72 kg/cm2.
- Laying Capacity: The laying capacity of the trenchless machine depends on drain depth, drain length, soil, site factors, shape of the plough, weight and power of the machine

3. FIELD INVESTIGATIONS AND MONITORING

3.1 The Experimental Areas (Haress area 1 & 2)

Haress area is situated in the Western Delta, at about 25-km south of Alexandrea, at latitude of 30° N and longitude of 29° 50′ E. The dominating soil texture in the area is loamy sand. The upper soil layer is characterized by the presence of shells, which varies considerably from point to another. The hydraulic conductivity of the soil was determined by means of the auger hole method (Van Beers, 1970). Measurements were performed in 2-meters holes at many points over the area. The areas of Haress 1 & 2 were irrigated from El Hager irrigation canal while the surface drains serving the two areas are Haress 1 drain, Haress 2 drain and El Amin drain (Figures 1 and 2) which discharges into Haress main drain. The subsurface drainage system installation started at the year 1997 and ended at the year 1998. Most of the area was designed with drain spacing of 60 m and depth of 1.5 at the outlet; while smaller portion was designed with a drain spacing of 80 m.

3.2 Selection of lateral drains(Choosing the laterals according to the construction date)

The first step, (Choosing of the laterals according to construction date).

The data collected was sorted according to the month and the year of construction, the laterals were classified into different groups according to the construction dates.

The second step,(Choosing of the laterals according to the soil type).

The collected soil samples were collected and analyzed. The soil texture varied from clay loam/sandy loams to clay/loam. The laterals within the same soil texture were gathered together.

The third step (Choosing of the laterals according to the soil hydraulic conductivity)

The data was sorted according to the hydraulic conductivity. The values of the hydraulic conductivity were classified into five groups as shown in Table 1.

*4. **The fourth step*** (Choosing of the laterals according to cultivated crop).

As crop is expected to influence irrigation amount and schemes, the laterals were grouped by crops as well.

Table 1. The hydraulic conductivity groups

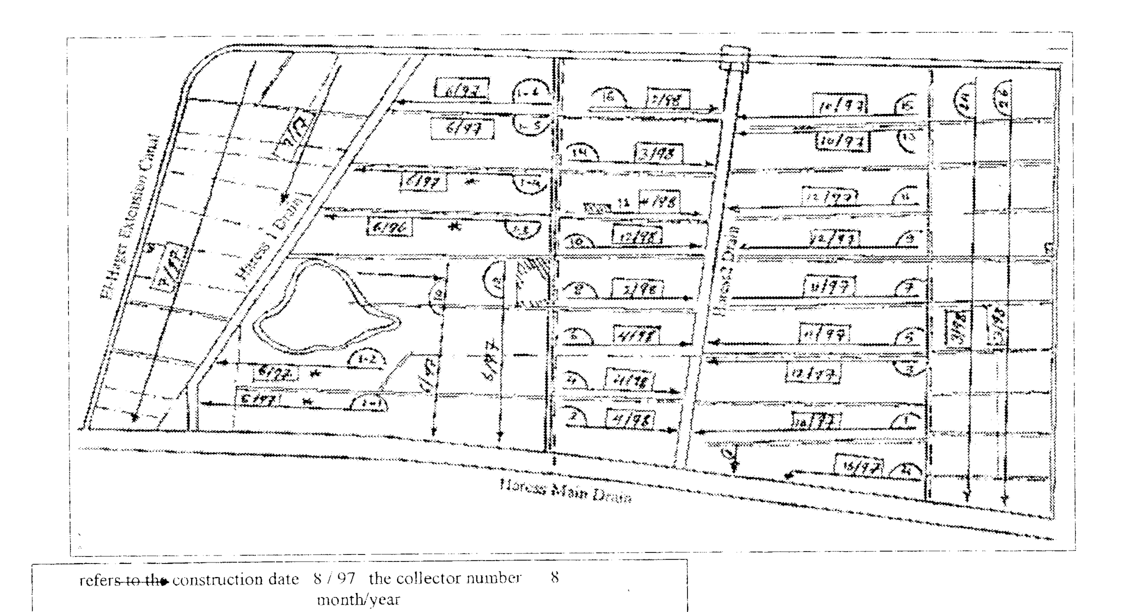
Group number	G1	G2	G3	G4	G5
H.C m/day	< 0.5	0.5 - 1.5	1.5 - 3.0	3.0 – 4.5	4.5 - 6.0

After sorting the laterals according to the previous criteria, it was tried to choose the laterals so that they cover wide range of construction date, soil texture, hydraulic conductivity and crops needless to mention that all the chose laterals need to be in good condition according to the Video Camera inspection. Unfortunately, only the construction date groups of zero to four months had wide range of soil conditions. Thus, all the chosen laterals were located in this group. One of the most important points taken into consideration is that the connection between the laterals and collector must be a manhole in order to measure the discharge of these laterals and also to know if the outlets of these laterals free or submerged.

3.3 Installation of the observation wells and piezometers

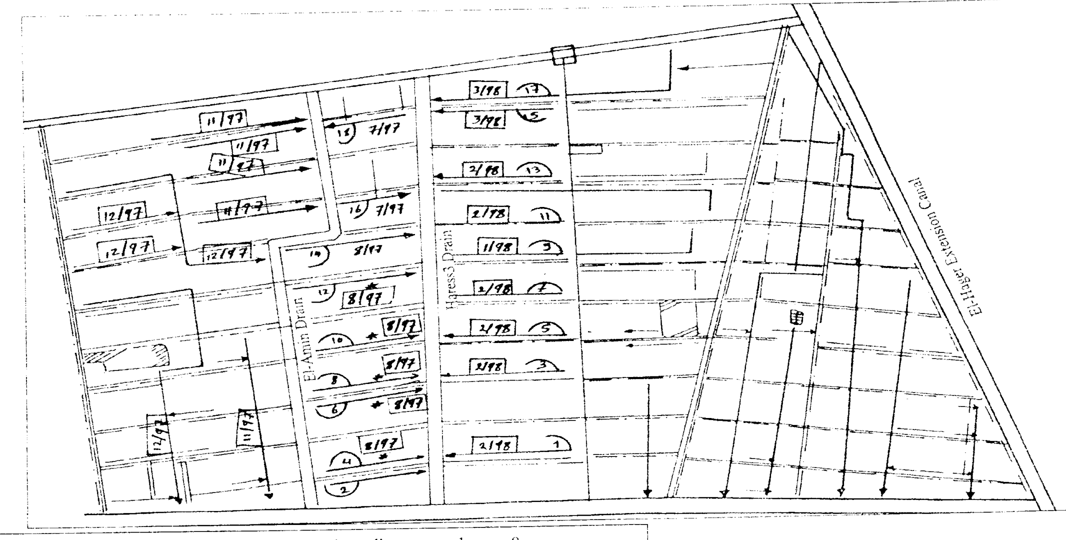
The watertable drawdown curves are used to compare between the hydraulic performance of the subsurface drainage systems installed by trencher and trenchless machines. The watertable depth was measured by means of observation wells. A small diameter (about 20 mm) plastic tube was set vertically in the soil. .

The piezometers and observation wells were installed in a set. Each set of piezometers and observation wells consists of two observations well; one at the left-hand side of the drainpipe and the other is at the right hand side of the pipe. At the middle, a piezometer pipe was installed inside the drainpipe to measure the overpressure. The selected sets were chosen to be far away from irrigation canals or open ditches that may affect the water table. The location of the sets must be within the same field in order to ensure homogeneity of the irrigation. The set also must have only one crop to be irrigated with the same amount of water Information about the observation wells such as the area, the collector no, the lateral no, the group, method of construction, the set no, the distance from the collector, the observation well, the values of the hydraulic conductivity, the bottom level, the top level, the number of draw down curve, and the summer crop, and the winter crop were collected.



refers to the construction date 8 / 97 month/year the collector number 8

Figure1. The layout of the drainage system at Haress area 1, constructed by trenchless machine.



refers to the construction date 8/97 the collector number 8
month/year

Figure 2 The layout of the drainage system at Haress area 1 which constructed by trencher machine

3.4 Monitoring programme

The programme of the measurements has been carried out for the five groups, which chosen according to the hydraulic conductivity values, in Haress area 1 and another five groups in Haress area 2. The measurements continued for two seasons, summer and winter of 1999/2000. The watertable data were collected in order to obtain the water table draw down curves. Two methods were used to collect these data as follows:

a. Manual measurement

Measurements were collected using a normal spring steel ruler. A slightly hollowed weight is fixed to the ruler and shortened to compensate for weight length. The hollowed end makes a distinct sound when it reaches the water surface.

b. Automatic measurements

An electronic device, called Diver, was used to measure and record watertable depth in a borehole. The Diver measures the height of a water column by measuring water pressure with a built-in pressure transducer. The Diver accurately measures the fluctuating water levels in the borehole at any pre-programmed frequency, each 15 minuets for example. There is a special software program collecting and analysing data recorded by means of Divers. The Diver was programmed and installed inside the pipe of the observation well or the piezometer. After 5 or 6 days, and when the watertable fluctuation ceased, the Diver unit was removed from The data was down loaded by means of a portable computer.

4. DATA ANALYSIS

4.1 Draw down curves

The hydraulic performance comparison between trencher and V-plow machines was evaluated, based on the behaviour of the water table draw down curves that was obtained from the observation wells, installed, 5 meters away from the drainpipe, on both sides. The daily measured water table depths were converted into water table head above the drain. These water table heads were plotted as functions of time for each drainage system for each irrigation event.

In order to compare the resulting large number of draw down curves, several parameters were calculated for each draw down curve. Each draw down curve was divided into three parts as shown in (*Figure 3*). The hydraulic head change rate was calculated for each part or several parts together. The head change for the first part, which is called the rising head part, was calculated by subtracting the head after irrigation from the head before irrigation. The head change rate for the second part, which is

called falling rate-1 was calculated by obtaining the tangent of the falling curve using the following equation:

$$\text{Falling rate}-1 = \frac{\text{head of first point of first tangent} - \text{head of second point of first tangent}}{\text{Time from the first point to the second point}}$$

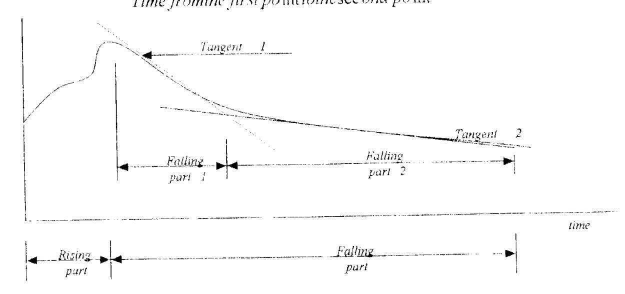


Figure 3. A schematic of a typical watertable draw down curve, showing the various stages that can be observed during an irrigation drainage unit.

The hydraulic head draw down rate for the third part is called falling rate-2, was calculated by considering the tangent of the falling curve by using the following equation:

$$\text{Falling rate}-2 = \frac{\text{head of first point of second tangent} - \text{head of second point of second tangent}}{\text{Time from the first point to the second point}}$$

Another parameter that incorporates the whole falling stage is considered in the analysis. This parameter termed falling rate 1+2, was calculated as follows:

$$\text{Falling rate } 1+2 = \frac{\text{head of falling part}-1 + \text{head of Falling part}-2}{\text{Time of falling part}+1 + \text{Time of Falling part}-2}$$

4.2 Factors affecting the hydraulic performance of field drains:

Many factors affect the hydraulic performance of field drains such as installation method, soil properties, irrigation quantity, outlet conditions and cultivated crop. In order to compare the effect of the installation method on the hydraulic performance of field drains, the measured draw down curves are divided based on the installation method (trencher and V-plow). Then, draw down curves from systems in one group is compared to those of similar systems in the other groups.

The factors, affecting the shape of draw down curves, can be grouped into soil conditions and installation method. In this study, the hydraulic conductivity was considered a representative of the soil properties that affect water flow towards the drains. The hydraulic conditions, which are influenced by several factors, depend partly on the soil hydraulic conductivity. For the same soil conditions, the irrigation quantity and outlet conditions become the most important factors. As direct measurement of the irrigation quantity was not conducted, it was essential to find an alternative parameter that can be used as indicator. While the irrigation quantity depends mainly on the type of the cultivated crop, the applied water quantity may still vary even for the same crop. Thus, the choice of cultivated crop as an indicator of the irrigation quantity is not suitable. Thus initial water table elevation, above the drain centre (hydraulic head), one day after an irrigation event, was considered the most suitable indicator for the irrigation quantity. It should be noted that the initial hydraulic head couldn't be used for comparing irrigation amounts on two different systems unless the soil properties are the same for the two systems. The initial hydraulic head was classified into four groups according to the statistical analysis as shown in Table 2. The cultivated crop was considered to influence the irrigation quantity and scheme only.

Table 2. The initial hydraulic head groups.

Initial hydraulic head group	h1	h2	h3	h4
Group range	< 0.21	0.22 – 0.43	0.44 – 0.60	> 0.60

5. RESULTS AND DISCUSSION

5.1 General:

The total number of observation for summer season is 178 (92 observations in fields that have V-plough-installed systems and 86 observations in fields that have trencher-installed systems). However, for winter season the total number of observation is 520 (242 observation for V-plow and 278 observation for trencher). The number of observation for the different hydraulic conductivity groups as shown in

Table 3. The initial hydraulic head is used as indicator of the irrigation quantity. The initial hydraulic head was divided into four group's h1, h2,

h3 and h4, respectively. The number of observations for each group is shown in Table 4.

Table 3. The number of observations for the different hydraulic conductivity group for summer and winter seasons.

Hydraulic conductivity group	G1	G2	G3	G4	G5
Summer Season					
V-plow	20	15	21	23	13
Trencher	20	22	20	21	6
Winter Crop					
V-plow	31	37	63	62	43
Trencher	55	73	43	65	42

Table 4. The number of observations for the different hydraulic head in summer and winter seasons.

Hydraulic Head group	h1	h2	h3	h4
Summer Season				
V-plow	23	43	13	9
Trencher	12	25	16	23
Winter Crop				
V-plow	98	84	35	24
Trencher	50	139	66	23

5.2 Water table draw down Curves

In this study, the water table draw down was considered the main indicator for evaluating the field drains performance. Many factors affect the hydraulic performance of field drains such as the installation method, the soil hydraulic conductivity and the initial hydraulic head above the drain after irrigation. In order to study the effect of installation method on the hydraulic performance of subsurface drains, draw down curves, of systems, which differ in the installation method only, are compared. Close examination of the systems, included in the study, show that no systems are identical. Thus, criteria for defining which systems can be considered identical is needed. This couldn't be accomplished until the collected data are examined.

Figure 4 shows a typical relationship of water table draw down, 5 meters away from the drain, with time, during the summer season, for two field drainage systems that were installed using the trencher and trenchless installation techniques, respectively. The hydraulic conductivity of the trencher-installed system is 3.5 m/d, while that of the

V-plow installed system is 3.7 m/d. Both systems were cultivated, with maize. These two systems are chosen because they yielded similar initial water table elevation above the drain centre, during some drainage events indicating a similar irrigation quantity at the corresponding events. As irrigation timing was different between the two systems, direct comparison between them was difficult. Figure 5 show a comparison between draw down curves of two drainage events, which have the same initial head above the drain centre. The event of the system that was installed using the trencher method, started on The 27^{th} of August, while the V-plow installed system event started on the 20^{th} of August.

The draw down for the trencher-installed system was faster than that for the V-plow installed system. This can be referred to the following reasons: the first is the trencher machine creates a zone of hydraulic conductivity in the trench area. The soil in this area is expected to settle down with time, thus the hydraulic conductivity will decrease gradually till it becomes close to that of the rest of the soil. The hydraulic conductivity of the trench is expected to play a large role in this study as the trencher installed systems one installed within four months prior to the study. The second reason is the smearing of the soil near the drains in the V-plow installed systems. This causes higher resistance to water flow in the vicinity of the drain. Figure (5) shows also that the draw down rate, 5 meters from the drain, for the trencher-installed system was higher than the V-plow-installed system during the early stage of the drainage event, when water table was relatively near the soil surface. On the contrary, the rate difference decreased as time passed by and water table dropped deep into the soil profile. This can be referred to the fact that significant portion of the water flow towards the drain takes place in the area near the drain and above the drain, for shallow water table conditions. For deep water table conditions, most of the activity takes place far from the drain and below the drain, where the effect of the installation technique is negligible.

Fous (1974) shows that 95% of the flow entering the drain comes within 5% of the drain spacing. Case b, shows a sketch of the water table profile after it dropped deep below the soil surface. In that case, the hydraulic head near the drain drops and most of the flow comes from the area far from the drain and enters the drain from its bottom half. Case c, show water table for an intermediate between case a and b. For that case, the water table is still close to the soil surface. For that case, a significant portion of the water, which enters the drain comes from the one near the drain and enters the drain through its top half.

5.3 Collective presentation of draw down data

The previous discussion shows the importance of draw down curves for evaluating the hydraulic performance of field drains. However, the large amount of measured data makes the comparison of individual events for different systems difficult. Thus, each draw down curve for each event was presented using the draw down rate.

First the draw down curves were divided into two main subsets according to the installation method. Figure 6 show a comparison of the falling rate-1 of the two main sets from the summer and winter season, respectively. The plots show that the draws down rates of the trencher-installed systems were higher than that of the V-plow-installed systems. This observation is the same as the one mentioned in the previous section. However, the difference between the two systems does not seen to be critical.

Then, each subset was classified according to the hydraulic conductivity groups G1, G2, G3, G4 and G5 (Table 1). Finally, each subset was divided into more subsets according to the initial hydraulic head at the start of drainage events h1, h2, h3, and h4.

The average falling rate-1 for the trencher and V-plow installed-systems, for h1 group, are plotted for each G-group, in Figure 7 a, for the summer season. It can be seen from the relationship that the average falling rate-1 for the trencher-installed systems is higher than that for the V-plow-installed systems by 10-25%. This variation can be referred to the fact that the trencher-installed systems exhibit less resistance to the water flow in the area near the drain because it has been from zero to four months since the construction of the systems. Thus, portion of the collected data for the trencher-installed systems, still exhibit higher trench conductivity. Another reason would be the smearing of the soil near the drain. It is worth mentioning that falling-rate-1 takes into account the early period, (of the drainage event) where most of the water, which enters the drain, comes from the area near the drain. Variation of rate-2 and rate1-2 is not as clear. This can be referred to the fact that, these two parameters take the effect of flow in the area far from the drain into consideration, which does not reflect the effect of the installation method

Figure 7 shows the relationship between the average falling rate-1 for the trencher and V-plow installed-systems, for h2, h3, and h4 groups, respectively, for the summer season. These relations exhibit the same trends. The trencher-installed systems average was higher than the V-plow average by 0-25%. However, the average falling-rate-1 for the same G-group increased with the increase of the H-group from H1 to H4.

Figure 8 shows the same kind of relationships, shown in Figure 7, but for the winter season. Similar to the summer season, the average falling-

rate-1 for the trencher-installed systems was higher than those of the V-plow-installed systems. However, the variation between the trencher and the v-plow was lower as the maximum variation in average falling-rate-1 did not exceed 15%.

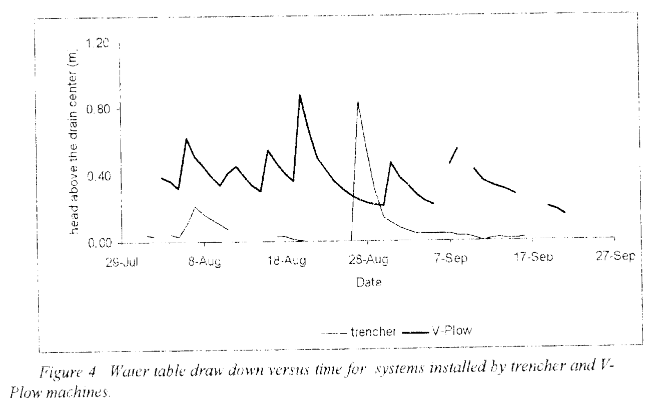


Figure 4 Water table draw down versus time for systems installed by trencher and V-Plow machines.

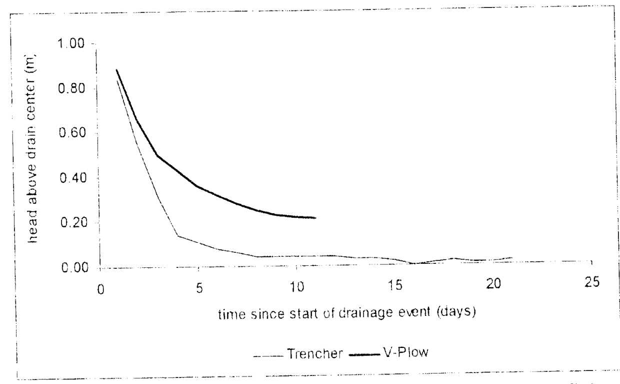


Figure 5 Water table draw down curve for trencher-installed and V-plow-installed systems.

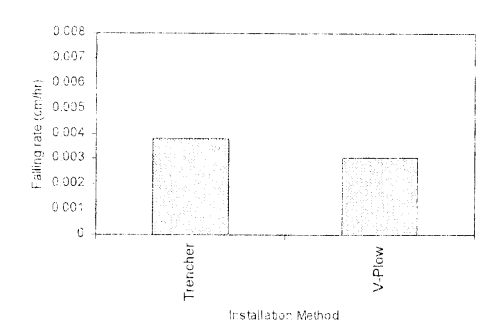


Figure 6 a) Comparison of the average draw down rate in case of trencher and V-plow during the summer season (all data).

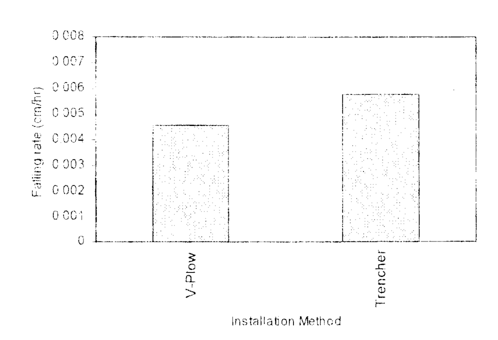
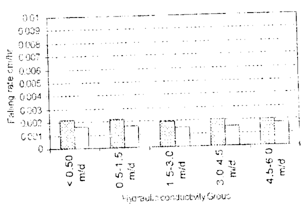


Figure 6 b) Comparison of the average draw down rate in case of trencher and V-plow during the winter season (all data).



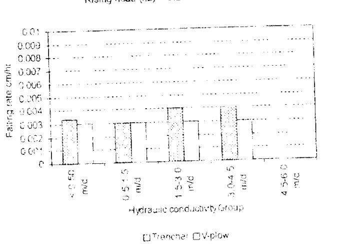


Figure 7 a) Comparison of the average draw down rate in case of trencher and V-plow during the summer season for initial head group h1 (head<0.21m).

Figure 7 b) Comparison of the average draw down rate in case of trencher and V-plow during the summer season for initial head group h1 (head 0.21m -0.43m).

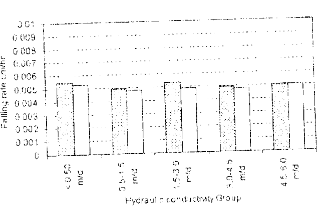
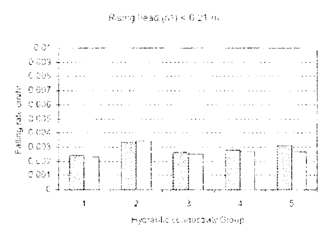


Figure 7 c) Comparison of the average draw down rate in case of trencher and V-plow during the summer season for initial head group h1 (head 0.44m -0.60m).

Figure 7 d) Comparison of the average draw down rate in case of trencher and V-plow during the summer season for initial head group h1 (head >0.60m)



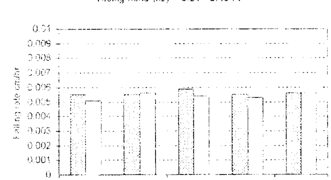
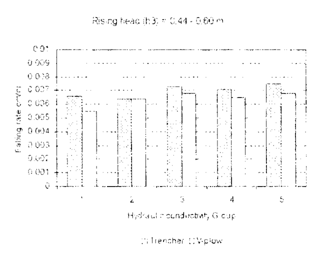


Figure 8 a) Comparison of the average draw down rate in case of trencher and V-plow during the winter season for initial head group h1 (head< 0.21m).

Figure 8 b) Comparison of the average draw down rate in case of trencher and V-plow during the winter season for initial head group h1 (head 0.21m -0.43m).



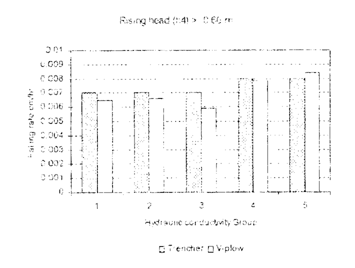


Figure 8 c) Comparison of the average draw down rate in case of trencher and V-plow during the winter season for initial head group h1 (head 0.44m -0.60m).

Figure 8 d) Comparison of the average draw down rate in case of trencher and V-plow during the winter season for initial head group h1 (head >0.60m)

6. CONCLUSION AND RECOMMENDATION

The V-plow construction technique was introduced to Egypt to overcome the construction problems in unstable and heavy clay soils that are experienced with trenching techniques in Egypt. The experiment showed clearly that the V-plough method is superior over the trenching method, for the previously mentioned soils under irrigated conditions.

In this paper, the hydraulic performance of field drainage systems installed by both trencher and V-plough has been studied in sandy loam soil, using the water table drawdown five meters away from the drains as an indicator of the hydraulic performance:

1. The draw down curve was divided into three parts: rising head part, fast falling part (falling rate-1) and slow falling water table (falling rate-2),
2. The most important factors, which affect the hydraulic performance of field drains, are soil hydraulic conductivity, irrigation quantity, and installation method.
3. The initial water table rises, one day after irrigation can be used as indicator for the irrigation quantity.
4. The fast drawdown rate (rate-1) indicates the hydraulic conditions, when the water table is high in the vicinity of the drain (shallow water table conditions). For deeper water table conditions, (rate-2 and rate1-2) better represent the hydraulic performance.
5. The fast drawdown rate (rate-1) for the V-plow installed systems was slightly lower than for the trencher system.
6. The difference can be a combination of the high hydraulic conductivity in the trench for trencher-installed system and the smearing of the area near the drain for the V-plow installed systems.
7. The falling rate-1 was higher for the trencher-installed systems than the V-plow-installed systems by about 21 % during the summer and winter seasons.
8. For the soil types, included in the study, the compaction of the area near the drain due to V-plow installation does not seem to be critical.

Based on the current study, the following recommendations for future studies and practices can be made:

1. It is recommended to repeat this study, later after trench area in trencher-installed systems settles down, so that it can be determined whether, the difference in hydraulic performance is temporary as permanent.
2. For the soil types, prevailing in Haress, the lower drawdown rate in case of V-plow does not seem to be critical. However, studies which relate short from economical gain due to the reduction of the

installation costs (when using the V-plow) technique to the loss which may take place due to the higher water table condition.

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الكفاءة الهيدروليكية للمصارف المغطاة المنفذة بالماكينات غير المخندقة

محمد بكر عبد الغني

معهد بحوث الصرف – المركز القومي لبحوث المياه

حدث تحول كبير في أنشاء شبكات الصرف الحقلي خلال العشرين سنه الماضية حيث أصبح تنفيذ هذه الشبكات يتم ميكانيكيا بدلا من تنفيذها يدوياً.

والأساليب المستخدمة حاليا في التنفيذ تهدف إلى تقليل الأيدي العاملة وزيادة كفاءة التشغيل والتي منها استخدام المواسير البلاستيكية وأيضا ماكينات التنفيذ غير المخندقة حيث يمكن لهذه الماكينات وضع المواسير تحت التربة بدون عمل خندق حفر وهى بذلك تفوق الماكينات المخندقة والتي تترك خندق الحفر مفتوحا بعد تنفيذ شبكة الصرف مما يتطلب إجراء عملية ردم لتلك الخنادق.

اختبرت هذه الماكينة غير المخندقة بتنفيذ شبكات صرف مغطى بمنطقة حارس (٨٠٠٠ فدان) بغرب الدلتا والتي تبعد حوالي ٢٥ كم جنوب مدينة الإسكندرية.

وأراضى هذه المنطقة ذات قوام رملي طمي حيث قسمت المساحة تحت الدراسة إلى قسمين

نفذ الصرف بأحدهما بالماكينات المخندقة ونفذ القسم الأخر بالماكينات غير المخندقة حيث قورنت الكفاءة الهيدروليكية للشبكات المنفذة بكلتا الطريقتين.. وقد تمت متابعة تذبذب الماء الأرضى كما تم رسم منحنياته كأحد الدلائل على كفاءة عمل الشبكة.

كما أستخدم جهاز الفيديوكاميرا لدراسة شبكة مواسير الصرف وأيضا قيست نفاذية التربة بالمناطق تحت الدراسة.

أوضحت نتائج الدراسة أن منحنى تذبذب الماء الأرضي يشمل ثلاثة أجزاء وهى الجزء الذي يرتفع نتيجة الري يعقبه الجزء الثاني وهو يمثل الهبوط السريع للماء الأرضي أما الجزء الثالث فهو يمثل الهبوط البطيء للماء الأرضي.

وقد وجد أيضا من نتائج الدراسة أن التوصيل الهيدروليكي للتربة وكمية ماء الري وأسلوب تنفيذ مواسير الصرف تؤثر كلها بصورة كبيرة على كفاءة عمل مواسير الصرف حيث أتضح أن المواسير التي نفذت بالماكينات المخندقة أعطت كفاءة أعلى بدرجة قليلة من تلك المنفذة بالماكينات غير المخندقة.

Drainage Criteria of Subsurface Drainage of Slightly-Sloping Lands in Arid African Regions

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ABSTRACT

This research aims to study the effect of drainage on lateral performance in the slightly sloping lands and find the drainage design criteria and parameters for such lands

Activities of this research were carried out in Seila Drainage Test Area (SDTA) in the Fayoum which represents the arid climate and the slightly sloping lands of slopes range between 0.5% and 2.0 %. SDTA was provided in 1991-1992 with a drainage system designed based on the principles of the flat areas except the lateral slopes, which follow the land slope

Lateral performance evaluation was carried out for nine laterals in SDTA. Four of these laterals were installed with the spacing that calculated by using the spacing formula, while the other five were installed with doubled spacing. To find the effect of slope on lateral performance a comparison was done between the results of the evaluation and the assumptions of the design. Based on the comparison, the drainage and design criteria for slightly sloping lands were developed

Watertable depth has been significantly lowered from 0.68 m before drainage to 1.06 m after drainage and more than 71% of the measured depth in SDTA was > 1.20 m below soil surface which can attributed to the presence of the slope. Results of the lateral performance in sloping lands indicated decrease or no overpressure in the drain pipes; passes more discharge reached to eight times for the same pipe diameter, decreases the required pipe diameters to 50% of the designed one; allows prolonging the laterals to any extent, decreases the required water head with about 30% and the water depth with 15% of the designed ones; widens the required spacing between laterals with 57%

In accordance with these results and the prevailing circumstances, the following design criteria are suggested for application in the slightly sloping lands: a) follow the land slope to design the lateral drains; b) use the same equation of flat areas to calculate the spacing between laterals and multiply the result by 1.5 to get the actual required spacing for the slightly sloping lands; c) pipe diameter could be reduced by 50%, d) prolong the lateral pipe to any extent.

1. INTRODUCTION

Many of the irrigated areas in Africa are located in arid and semi-arid regions. They are characterised by the presence of slight slopes. The soil profile in such areas is characterised by the presence of a rocky layer nearby the soil surface which causes high watertable level, increase the lateral seepage from the higher neighbouring areas and salinity problems.

For these reasons, the design of subsurface drainage for such areas needs different design criteria from those used in flat lands or in steep sloping areas, which have been studied in many parts of the world.

The common practice, for drainage system design in Egypt, is to apply the principles and criteria of the flat areas all over the country. But in some areas, which have slight slopes such as in the Fayoum Governorate and the newly reclaimed lands adjacent to the desert, application of such principles and criteria may not be appropriate. The Fayoum Governorate was selected to represent slightly sloping lands to conduct this research.

In arid and semi arid areas, the major objective of drainage is salinity control. Another objective is to remove the excess water. Excess water may induce high water tables, which, if saline, contribute to salinization of soils.

It was found that the desert climate zone in Africa occupies 29% of the total land area, while arid and semi arid climates occupy 17 and 8%, respectively. The total area that has aridity phenomena is 54% of the continent's area (FAO, 1987).

According to El-Hassanin (1995), the extremely arid regions in Africa are located in the Great Sahara and in the Namibian Desert, while the arid regions are located in the south to the Great Sahara and in the Kalahari Desert. The semi arid regions are mostly located to the south of the arid areas.

Amer et al, (1989) reported that the drainage criteria for the Egyptian typical conditions (arid, irrigated and flat lands) are as follow:

- The steady state criteria require a dewatering zone of 1.0m depth below soil surface, therefore an average depth of 1.4 m was considered to be an optimum choice for the lateral drains. Thus, the design watertable height midway between drains is 0.40 m above the drain level.
- The average field drain length is 200 m and the slope varies between 0.1 and 0.2 %.
- A steady drainage rate of 1.0 mm/day is considered to be a sufficient design criterion for dewatering zone of 1.0 m below soil surface. However, in the northern parts of the Nile Delta it is increased to 1.25 mm/day till contour +3 m MSL and 1.5 mm/day north of this contour.
- In Egypt, a minimum inside diameter for PVC pipes of 72 mm is used for standard lateral drains.
- Pipe diameters are calculated using the criterion that no overpressure occurs at the beginning of the lateral.

Smedema and Rycroft (1983) stated that when land slope is > 0.5% it is considered sloping land. Sevenhuijsen (1994) mentioned that the lands have slopes of more than 2% are sloping areas. Boonstra (1994) reported that it is slightly sloping land when the slope ranges between 1 and 5%

Eissa (1998) mentioned that in general, the gradient of the watertable in slightly sloping lands follows the land slope. Van Hooren and van der Molen (1980) mentioned that the ground water flow may cause water logging at certain sites, such as where the slope of the land changes or where locally the impervious base forms a threshold or barrier. It may also rise to the ground surface at foot slope or at the contact of pervious and poorly pervious layers outcropping alongside the slope. They added that, in arid regions, these sites are often characterized by salinization.

When designing a drainage system for a sloping area, the maximum permissible flow velocity should not exceed certain limits which are considered in the German standards as 1.5 m/sec (Ritzema, 1994). Amer (1969) found that as the slope increases silt deposits decrease.

Ritzema (1994) stated that when a hillside is drained by a series of parallel drains, the situation is as depicted in Figure 1. The watertable height, h, above drain level is now not midway between the drains but is closer to the downstream drain.

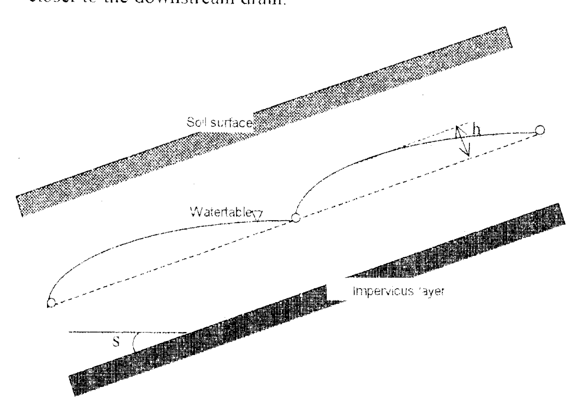


Figure 1: Flow to parallel drains in a homogenous soil overlying a sloping impervious layer.

In order to achieve the objectives of this research, it was necessary to highlight firstly the circumstances of the Seila Drainage Test Area (SDTA) in the Fayoum Governorate (Figure 2), which is selected to carry out the research and to represent the slightly sloping lands in Egypt.

Objectives of this research are:

- Testing the effect of applying the subsurface drainage based on the flat design principles on slightly sloping lands;

- Finding the most appropriate drainage design criteria and parameters for slightly sloping lands.

2. MATERIAL AND METHODS

2.1 Seila Drainage Test Area

2.1.1 Location and layout

Seila Drainage Test Area (SDTA) is located in El Moqatla village, 25 km north-east of the Fayoum city (Figure 2).

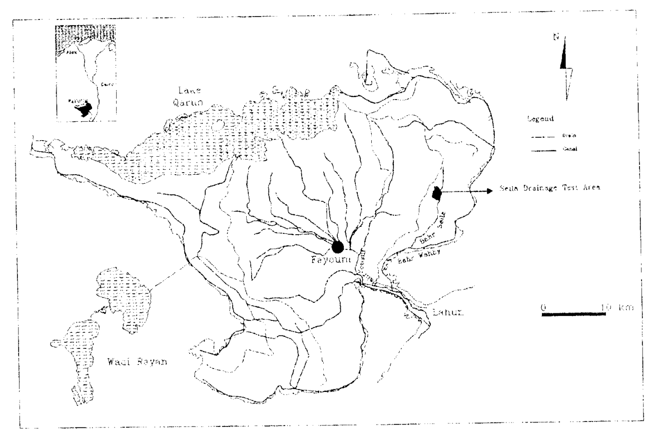


Figure (2): The Fayoum Depression and the location of Seila Drainage Test Area.

SDTA has an area of 550 feddans with an average length of about 2100m and an average width of about 1100m. SDTA is bounded by El Moqatla open drain to the West, Bahr El Roda and Mesqat El Hariq El Sharqi to the East, Bahr El Gafada to the South and an open ditch to the North (Figure 3). SDTA was characterised by high soil salinity and alkalinity and high watertable depth which created drainage problems.

2.1.2 Topography

The topography in most of the area is quite regular with slopes varying between 0.5 and 1.2% in the general direction East-West. The area is leveled in some locations into terraces with different levels of 0.5-1.5m between each.

2.1.3 Drainage criteria

The drainage criteria required for the design of the drainage system were:

a) Required watertable depth: One meter was selected as required watertable depth for the design of the lateral drains in SDTA.
b) Drainage coefficient: A value of 1.2 mm/day was resulted from the determination of the different elements of the drainage coefficient for SDTA.

2.1.4 Drainage design criteria

Drainage design criteria are those elements required for the design of the drainage system and related to the depth and the spacing of the lateral drains. These elements are:

- The lateral drain depth was chosen as an average of 1.4m below soil surface, a watertable depth of 1m below field level and an allowable increase (h) of waterlevel midpoint between lateral drains of 0.4m.
- Lateral drain slope was taken for design as 10 cm /100m. The actual slopes during installation ranged between 20-72cm/100m depending on the available land slope in SDTA.
- For lateral drain diameters, the standard 80mm (72mm internal) pipe diameter was selected to be used for lateral drains.

2.1.5 Drain Spacing

Drain spacing was calculated by the Toksoz-Kirkham (1971) solution depending on the following factors of SDTA:

- Soil hydraulic conductivity, K in m/day (K values as determined from the area).
- Depth to the impermeable layer, D (4 m)
- Allowable increase in water level at midpoint between drains, h (0.4m)
- Drainage Coefficient, q (1.2 in m/day)

$$\frac{h}{D} \times \left(\frac{K}{q} - 1 \right) = \frac{L}{D} \times F_k$$

Where:

F_k = Kirkham factor

In accordance to the above factors for all locations, for which K values were available, the drain spacing calculation have been made. Spacings between laterals calculated by the formula vary considerably from 4.5 to 78m. For practical reasons it was proposed to install into the area only spacings of 15 and 30 m.

The drainage system was installation during the year 1991 and the first quarter of year 1992.

2.2 Monitoring procedure after drainage installation

2.2.1 Observation points

To study the effect of the drainage system implementation on watertable depth, a network of observation wells was established in May 1992 at points located midway between drains at 14 laterals. These points were selected to represent both the investigations of the watertable depth for SDTA and the study of the lateral performance too. Groundwater depth readings were collected from the observation wells once every 8 days.

Nine laterals were selected to study the lateral performance. Four of those laterals were installed according to the design (treatment 1). The other five laterals were installed by using doubled spacing, which changed from 15 to about 30m (treatment 2). Groundwater depth readings were collected from the observation wells at these laterals twice a day for a period of one month.

Table (1) presents the tested laterals, the relevant treatment, actual spacing among laterals and the actual slope of each. Those laterals are showed in Figure (4).

In the drain catchment area, a network of observation wells and piezometers similar to those proposed by (FAO 1976) was carried out to study the lateral performance (Figure 4). Observation wells at ½ laterals spacing (S) are to measure the water level at the midway between laterals (htot.), while the observation well beside the lateral (B) of about 40 cm distance is to measure the vertical difference between the center of the lateral pipe and the water level at a distance just beyond the trench wall (he). The piezometer (P) is to measure the overpressure inside the lateral drain.

Table 1 The treatments and actual slope of the tested laterals

Lateral No.	Description*	Treatment design	Actual spacing (m)	Actual slope (cm/100m)
4/1	L28/B1	15m designed/15m installed**	15.5	47
5/1	L40/B1	15m designed/15m installed**	14.5	50
2/3	L11/B3	30m designed/30m installed**	29.0	34
4/3	L22/B3	30m designed/30m installed**	30.0	46
8MC	L18/MC1	15m designed/30m installed***	25.0	51
9MC	L19/MC1	15m designed/30m installed***	25.0	51
9/3	L62/B3	15m designed/30m installed***	31.5	41
10/6	L45/B6	15m designed/30m installed***	30.0	61
X/1	L5/B1	15m designed/30m installed***	30.0	35

* L28/1 is the lateral No. 28 at the sub-collector No. 1, ** Treatment1, *** Treatment2

Contemporary with the monitoring of groundwater depths, the discharges of the lateral drains were measured in their outlets in the relevant manholes. Besides the previous data collection, the following extra observations were done:

- Survey of the cultivated plot locations, and sizes within the catchment area;
- Start/end time and date of all irrigation gifts.

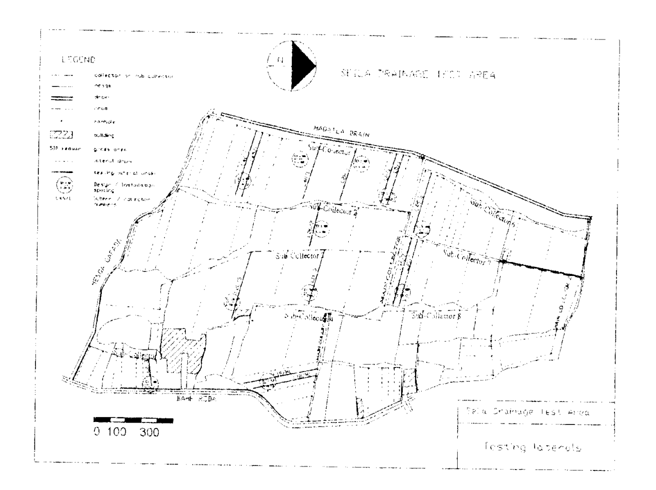


Figure 3 Locations of the tested laterals

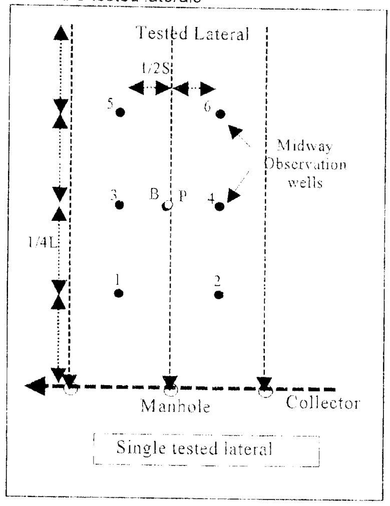


Figure 4 Monitoring network in the lateral catchment area

2.3 Evaluation of the lateral performance:

Evaluation of the lateral performance was carried out by comparing the results of the lateral performance study with the assumptions and the drainage criteria used for the design of the installed drainage system in SDTA. This procedure was carried out for the laterals of both treatment 1 and treatment 2. The assumptions and criteria of the evaluation relevant to the circumstances of SDTA are:

- For watertable depth (WT) performance (taken into consideration the actual drain depth of the tested laterals) as presented in Eissa, M. and M. Shaaban. 1998:

WT between the upper and lower boundaries is Good performance

WT higher than the upper boundary indicate moderate, poor and very poor depending on their situation

WT lower than the lower boundaries is Good performance and over drainage.

- The typical average of the hydraulic head above drain level (or the allowable increase in waterlevel at midpoint between drains) is 0.4 m with the same consideration as above (Eissa, M. and M. Shaaban 1998).
- The typical average of the recession of the watertable during 6 days after irrigation is 0.7 m with the same consideration as above (Eissa, M. and M. Shaaban. 1998).
- No occurrence for overpressure in the drain pipe, considering the non-steady state conditions in this research case (FAO 1976).
- The actual spacing measured from the field for the studied laterals was compared with the one calculated (L, m) by Hooghoudt equation as presented in Smedema and Rycroft (1983) based on the obtained hydraulic conductivity (K, m/d), drainage coefficient (q, m/day), allowable increase in waterlevel at midpoint between drains (h, m) and the equivalent depth to the impermeable layer (d, m).

$$L^2 = \frac{8Kdh + 4Kh^2}{q}$$

When the calculated spacing is around the value of the actual spacing, it is acceptable. When it is less (narrower) than the actual value it is an indication for the good performance and the improvement of the system due to the presence of the slope. Values of more than the actual ones are indication for poor performance of the system. Positive change percentage ((actual-calculated)*100/actual) is considered an improvement percentage for the lateral performance.

- The design drainpipe diameter for the studied laterals was compared with the (theoretically required) one which is calculated by using the design equation of corrugated pipe diameter presented in Smedema and Rycroft (1983) based on the actual pipe slope and the other design parameters selected for the area of the discharge along the pipe, Q (m3/sec), the pipe internal diameter, d (m) and the hydraulic gradient, i (m/m).

$$Q = 38\, d^{2.67}\, i^{0.50}$$

The reduction of the drainpipe diameter than the design one is an indication for the improvement in the pipe diameter due to the presence of the slope. Negative change percentage is calculated to obtain the improvement percentage for the pipe diameter.

- The design drainpipe capacity for the studied laterals (1.2 mm^3/sec) was compared with the one calculated by the above equation of the pipe diameter based on the actual pipe slope and the other design parameters selected for the area.

The increase of the drainpipe capacity than the design one is an indication for the improvement in the pipe diameter due to the presence of the slope. Positive change percentage is calculated to obtain the improvement percentage for the pipe capacity.

- The resistance parameters are:
  - *Entrance head loss (h_e)*, which is the vertical difference between the center of the lateral drainpipe and the water level at a distance just beyond the trench wall.
  - *head loss fraction (h_e/h_{tot}), where h_{tot} is the water level at the midway between laterals.*

Values and ranges of these parameters are compared with those mentioned in the FAO (1976) as follow:

  - Good performance for he < 0.15m and he / htot < 0.2
  - Moderate performance for he 0.15-0.30m and he / htot 0.2-0.4
  - Poor performance for he < 0.30-0.45m and he / htot 0.4-0.6

- The height of sediments inside the drainpipe is compared with the designed safety factor of the pipe diameter, which equals 3 cm in our case.
- T-Test and regression analysis were used for data analysis and the evaluation of the effect of the drainage implementation on different parameters of soil, water, crop and lateral performance.

3. RESULTS AND DISCUSSION

3.1 Effect of Drainage on Groundwater depths:

The main objective of drainage system implementation is to reduce the ground water level. Evaluation of the effect of the drainage system implementation was carried out for the whole area for a long period starting just after drainage system installation from 1992 till August 1999.

The drainage criterion prescribed that the groundwater depths should be lowered to a depth of about 1m (or in another words between 0.80 - 1.20 m) below soil surface.

As an effect of drainage system implementation, the average groundwater depth decreased sharply just after drainage from 0.68 to 1.04m below soil surface. Figure (5 presents the change percentage of different classes of watertable depth in SDTA after drainage system implementation.

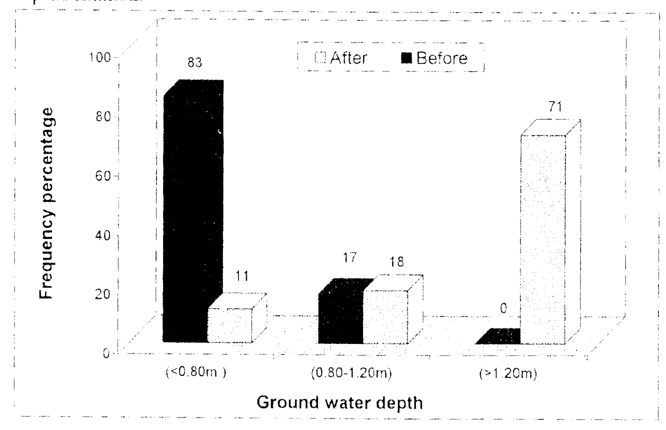


Figure (5) Percentage of changing in ground watertable depth due to drainage implementation

The figure showed that after drainage system implementation 89% of the study area has a groundwater depth of > 0.80 m below soil surface, of which 71% has a groundwater depth of > 1.20 m below soil surface. This result reveals that the drainage effect in the area did not meet only with the groundwater depth criterion but also exceeded and the area is subjected to over drainage which can be attributed to the presence of the soil slope.

3.2 Testing the effect of the slope on the performance of the drainage system:

As previously mentioned, the drainage system was designed in SDTA based on the flat principles such as:

- Using the Toksoz-Kirkham equation to calculate the spacing between laterals;
- Pipe diameters were calculated based on the current used slope.
- Maximum permissible velocity and the available pipe diameter in the market.
- Determining the required watertable depth, the hydraulic head midway between laterals and the depth of lateral pipes by the same principles of flat lands.
- The length of the laterals are limited to 200-300 m as they used in the flat lands due to the smooth slope of the traditional systems implemented in such lands.

The exception of these principles was the determination of the slope of the lateral pipes, which were designed to follow the land slopes. These pipe slopes are categorized, in accordance to the literatures, as slightly slope. The lateral pipe slopes in the study area expresses the land slope.

The description of the nine laterals that were selected for studying the lateral performance as well as the relevant treatment and the actual slope of each are presented in Table (2).To separate the effect of the land slope from those effects that could be occurred due to drainage implementation, it was necessary to carry out this lateral performance study as close as possible from the time of drainage system completion.

Evaluation parameters of the lateral performance study were compared with the assumptions as mentioned above.

Table (2): The treatments under study and actual slope of the tested laterals

Lateral code	Description	Treatment	Actual slope (cm/100m)
4/1	L28B1	According to design (Treatment 1)	47
5/1	L40B1	According to design (Treatment 1)	50
2/3	L11B3	According to design (Treatment 1)	34
4/3	L22B3	According to design (Treatment 1)	46
8MC	L18MC1	Double spacing (Treatment 2)	51
9MC	L19MC1	Double spacing (Treatment 2)	51
9/3	L62B3	Double spacing (Treatment 2)	41
10/6	L45B6	Double spacing (Treatment 2)	61
X/1	L5B1	Double spacing (Treatment 2)	35

Table 3 and Table 4 present the result of hydraulic and resistance parameters that used for the evaluation of the drainage system performance and their comparison to the lateral design assumptions.

As shown in the tables, the results of the lateral performance indicate that the performance, in an average, is "Good" for the laterals of treatment 1 group and "Moderate to Good" for the laterals of treatment 2. The results meet the expected outputs of the research that the laterals of the Treatment (1) should give good performance and the laterals of Treatment (2) should give considerable performance improvement due to the land slope.

Table (3) The evaluation of hydraulic parameters of the tested lateral during 1995

Lateral No.	Recession rate in 6 days from irrigation (cm)	Drain depth (m)	Average head (m)	Average depth (m)	Drain performance evaluation
4/1	67	1.17	0.16	1.01	Good
5/1	76	1.31	0.30	1.01	Good
2/3	37	1.21	0.34	0.87	Good
4/3	45	1.38	0.33	1.05	Good
Average treatment 1	56	1.30	0.28	1.02	Good
8MC	53	1.38	0.27	1.11	Good
9MC	54	1.38	0.37	1.01	Good
9/3	42	1.11	0.43	0.68	Good
10/6	38	1.31	0.41	0.90	Good
X/1	37	1.13	0.62	0.51	Moderate to Good
Average treatment 2	45	1.26	0.42	0.84	Good

Table (4): The evaluation of resistance parameters of the tested lateral during 1995

Lateral No	Entrance head loss (h_e)	head loss fraction (h_e/h_{tot})	Drain performance evaluation
	(m)	-	
4/1	0.13	0.26	Moderate to Good
5/1	0.10	0.11	Good
2/3	0.09	0.13	Good
4/3	0.25	0.28	Moderate
Average treatment 1	0.14	0.20	Good
8MC	0.23	0.10	Moderate to Good
9MC	0.20	0.08	Moderate to Good
9/3	0.37	0.55	Poor
10/6	0.06	0.11	Good
X/1	0.40	0.91	Poor-Very poor
Average treatment 2	0.25	0.35	Moderate

Figure (6 shows averages of performance parameters for treatments under study compared to the upper and lower boundaries of the design assumption values.

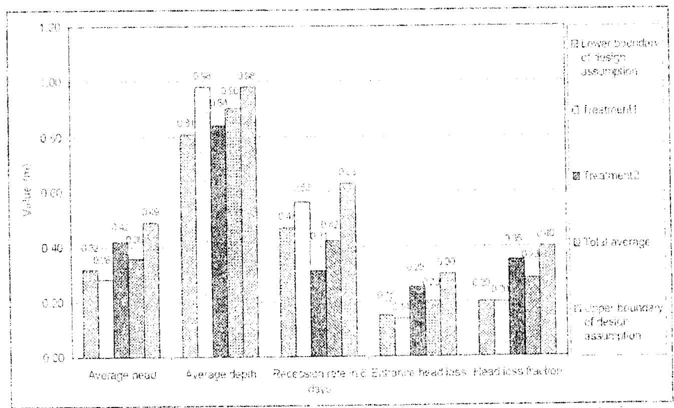


Figure (6). Averages of performance parameters for treatments under study compared to the design assumption values

The averages of performance parameters for both treatments (1 and 2) locate in between the two boundaries of design assumptions and show that the performance of Treatment (2) is not as good as of treatment (1) which is logic but also indicate a reasonable improvement that can be attributed to the presence of slope. This result is as the same as the one got from As shown in the tables, the results of the lateral performance indicate that the performance, in an average, is "Good" for the laterals of treatment 1 group and "Moderate to Good" for the laterals of treatment 2. The results meet the expected outputs of the research that the laterals of the Treatment (1) should give good performance and the laterals of Treatment (2) should give considerable performance improvement due to the land slope. (Table 3)

The upper and lower boundaries confine the range of the good performance of every category for different parameters. Table (5) shows the average overpressure during the study period. The average of the first treatment is less than 1cm and occurred only during the first few days after irrigation due to the water discharge from the drained area throughout the length of the lateral pipe.

The resulted average value compared to the diameter of the tested lateral pipes is ineffective and could be neglected as the same as the average of the second treatment that reached only 1cm.

Table 6 presents a comparison between the results of this research where it shows a positive change (improvement) in the lateral spacing of an average of 45%.

Table 5 The overpressure of the tested laterals during 1995

Lateral No.	Overpressure at maximum discharge (m)	Average overpressure value (m)	Occurrence after irrigation (days)
4/1	0.05	0.006	3
5/1	0.03	0.007	4
2/3	0.03	0.006	4
4/3	0.08	0.009	3
Average treatment 1	0.05	0.007	3.5
8MC	0.05	0.006	3
9MC	0.06	0.007	3
9/3	0.05	0.008	3
10/6	0.05	0.016	6*
X/1	0.06	0.013	6*
Average treatment 2	0.06	0.010	4.2
Total average	0.06	0.009	4

* Irrigation continued for several days in different areas within the lateral catchment.

Table 6 Improvement percentage in the lateral spacing of different treatments

Lateral No.	Hydraulic conductivity (calculated) (m/day)	Actual spacing (m)	Spacing based on K-calculated* (m)	Change percentage %
4/1	0.05	15.5	15	3
5/1	0.02	14.5	8	45
2/3	0.10	29.0	19	34
4/3	0.05	30.0	15	50
Average treatment 1				33
8MC	0.05	25.0	15	40
9MC	0.05	25.0	15	40
9/3	0.02	31.5	8	75
10/6	0.03	30.0	10	67
X/1	0.05	30.0	15	50
Average treatment 2				54
General average				45

* by using Hooghoudt Equation

The results also show that there is a considerable difference between the average of the two treatments and there is much difference between the individual values. The effect of slope on lateral performance as presented in Table 6 gave a high significant effect in accordance to the t-test (Table 7).

Table (7): Result of the t-Test of the effect of drain pipe slope on the lateral performance.

Parameter	t Stat	t Critical one-tail	t Critical two-tail
(1%)	15.31	1.74	2.12

One of the main effects of increasing the lateral pipe slope is the increase of the water velocity in those pipes. Consequently, this effect increases the pipe capacity too or decreases the required pipe diameters. The drainage design coefficient was selected as 1.2mm/day and the pipe slope is 0.10m/100m. The pipe diameter that calculated according to the design and actual slopes, in addition to the factors of drained area and drainage design coefficient, are presented in Table. The average change percentage is 50% or reduction in the pipe diameter with 50% of the design one. According to the result of the t-test, it gave a high significant value for the effect of applied pipe slope on the reduction of pipe diameters as presented in Table 8.

The only objection of the obtained result of increasing the pipe slope is that the high water flow velocities disturbs the soil particles surrounding the pipe and encourages the invasion of soil particles to clog the pipe

drains. Therefore, the sediments inside drain pipes were studied during 1995. The results are presented in Table 9.

It is evident that after 3 years from drainage implementation, the average height of sediments in the tested lateral pipes is only 1mm and the average decrease in pipe capacity is 0.23% of the total pipe capacity. This result reveals that no sedimentation has been occurred due to the used pipe slope in the study area. The reason can be referred to the abundance of the heavy soil texture in the study area, which is more stable towards the generated high velocities in the pipes.

Table (8): Designed and actual pipe diameter of the tested laterals

Lateral No	Design pipe slope	pipe diameter	Actual pipe slope	Required Pipe diameter	Change in diameter
	m/100m	mm	m/100m	mm	%
4/1	0.10	26	0.47	19	-0.25
5/1	0.10	27	0.50	20	-0.26
2/3	0.10	42	0.34	26	-0.39
4/3	0.10	56	0.46	28	-0.50
8MC	0.10	55	0.51	24	-0.56
9MC	0.10	59	0.51	24	-0.60
9/3	0.10	49	0.41	19	-0.61
10/6	0.10	54	0.61	19	-0.66
X/1	0.10	64	0.35	23	-0.64
Average	0.10	48	0.46	22	-0.50

Table (9): Sediments inside the pipes of the tested laterals during 1995

Lateral No.	Height of sedimentation in the pipe	Sedimentation as percentage of the pipe capacity
	mm	%
4/1	0.5	0.02
5/1	0.3	0.00
2/3	0.8	0.10
4/3	0.9	0.15
8MC	0.5	0.02
9MC	0.1	0.00
9/3	0.0	0.00
10/6	3.0	0.50
X/1	4.2	1.33
Average	1.1	0.23

As previously mentioned, the increase of pipe slopes increases the capacity of those pipes. Table (10 presents the change percentage occurs in the pipe capacity of the lateral pipes due to the increase of pipe slopes. The average value of the actual pipe capacity calculated increased to about eight times comparing with the design one.

Table (10 Designed and actual pipe capacity of the tested laterals

Lateral No.	Design pipe slope	Design pipe capacity	Actual pipe slope	Actual pipe capacity	Change in capacity
	m/100m	mm/day	m/100m	mm/day	%
4/1	0.10	1.20	0.47	2.17	117
5/1	0.10	1.20	0.50	2.23	123
2/3	0.10	1.20	0.34	3.69	269
4/3	0.10	1.20	0.46	6.43	543
8MC	0.10	1.20	0.51	9.03	803
9MC	0.10	1.20	0.51	11.29	1029
9/3	0.10	1.20	0.41	12.15	1115
10/6	0.10	1.20	0.61	17.28	1628
X/1	0.10	1.20	0.35	14.97	1397
Average	0.10	1.20	0.46	8.80	780

The pipe capacity shows high significant increase due to the effect of the pipe slope as presented in Table (11of the t-Test analysis.

Table (11) Result of the t-Test of the effect of pipe slope on the pipe capacity.

Parameter	t Stat	t Critical one-tail	t Critical two-tail
(1%)	1.12	1.75	2.07

Moreover, the land slope permits the opportunity to prolong the lateral to more than what is designed in the flat areas. The limitations for the design of the length of the laterals are the land slope, the diameter and capacity of the pipe.

3.3 Drainage design criteria for the slightly sloping lands

Based on the previous results, the slightly sloping lands, represented by the pipe slope of the tested laterals, can show the following effects:

- Prevents or decreases the occurrence of the overpressure to the least extent (Table 5).
- Passes more discharge of drainage water reaches eight times as the design one for the same pipe diameter (Table (10).
- Decreases the required pipe diameters to 50% of the design one (Table 8).
- Allows prolonging the laterals to any extent whenever the land slope and the pipe diameter and the land layout permit that.

- Decreases the required head with about 30% and the depth with 15% of the design ones of the design ones (As shown in the tables, the results of the lateral performance indicate that the performance, in an average, is "Good" for the laterals of treatment 1 group and "Moderate to Good" for the laterals of treatment 2. The results meet the expected outputs of the research that the laterals of the Treatment (1) should give good performance and the laterals of Treatment (2) should give considerable performance improvement due to the land slope.(Table 3)
- Widens the required spacing between laterals with 45% (Table 6).
- In accordance to these results and the prevailing circumstances of the study area (SDTA), it is suggested that to formulate modified design criteria applied for the slightly sloping lands, following is considered:

  Follow the land slope to design the lateral drains.
- Use the same equation for calculating the spacing between laterals as flat areas and multiply the result by 1.5 to get the actual required spacing for the slightly sloping lands.
- In case of not widening the spacing between laterals as mentioned in item b), pipe diameter could be reduced by 50%.
- Whenever the land slope permits, prolong the lateral pipe to any extent. Only consider the different required diameter lengths with respect to capacities of the pipe.

4. CONCLUSION

The design of subsurface drainage for slightly sloping lands needs different design criteria from those used in flat lands or in steep sloping areas, which have been studied in many parts of the world. Therefore, finding the most appropriate drainage design criteria and parameters for slightly sloping lands was the main objective of this research.

In accordance with the obtained results and the prevailing circumstances, the following design criteria are suggested for application in the slightly sloping lands: a) follow the land slope to design the lateral drains; b) use the same equation of flat areas to calculate the spacing between laterals and multiply the result by 1.5 to get the actual required spacing for the slightly sloping lands; c) in case of not widening the spacing as mentioned in item b), pipe diameter could be reduced by 50%; d) whenever the land slope permits, prolong the lateral pipe to any extent, only consider the pipe diameter.

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الملخص العربي

معايير الصرف المغطى فى الأراضى شبه المنحدرة بالمناطق الإفريقية الجافة

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يقع العديد من الدول الأفريقية ضمن الإقليم الجاف وشبه الجاف وتتميــز مساحات واسعة من الأراضي المروية بهذه الدول بأنها شبه منحدرة . وتقوم هذه الدول بالتخطيط لإدخال نظـم الري والصرف والزراعة الدائمــة بها... ولذلك تحتاج مثل هــذه الأراضــي إلــى اسـتنباط الأسس والمعايير التي يتم بناءا عليها تصميم نظم الصرف المغطى بدلا من تطبيــق الأســس الخاصة بالأراضي المنبسطــة .

ولقد تــم اختيار منطقة سيلا بمحافظة الفيوم والتي تمثل الأراضي شبه المنحدرة وكــذلك أراضى المناطق الجافة وشبه الجافة لتنفيذ أنشطة هذا البحث ، ويهدف هذا البحث إلى استنباط المعايير التصميمية لشبكة الصرف في الأراضي شبه المنحدرة .

أظهرت نتائج دراسة تقييم أداء المصارف الحقلية المنفذة في الأراضي شــبه المنحــدرة والتي تمثلها انحدارات المصارف الحقلية المنفذة بمنطقة الدراســة النتــائج التاليــة: منــع أو نقص حدوث ضغوط داخل مواسير الصرف ، إمرار المزيد من مياه الصرف والتــي تصــل ثمان مرات قدر الحجم المصمم عليه مواسير الصرف ولنفس أقطار المواسير ، اختزال أقطار مواسير الصرف إلى 50% من القيم التصميمية لأقطار المواسير ، إمكانية امتــداد الحقليــات إلى أي طول طالما أن انحدار الأرض وأقطار المواسير ومخارج الصرف تســمح بـــذلك ، اختــزال الضاغط المطلوب بمقــدار 30% وعمق مواسيــر الصــرف بمقــدار 15% مــن العمق التصميمي ، زيادة المسافة بين الحقليات بمقدار 45% من المسافة التصميمية .

بناءا على النتائج السابقة والظروف السائدة بالمنطقة يقترح تطبيق المعــايير التصــميمية التالية في تصميم شبكات الصرف فى الأراضى شبه المنحدرة . أ) تتبع المصــارف الحقلية في تصميم انحداراتها انحدارات الأرض ، ب) يمكن استخدام معادلــة حســاب المســافات بــين المصارف في الأراضي المستوية مع رفع قيمه هذه المسافة بمقدار 150% للحصــول علــى

المسافات المطلوبة بين مصارف الأراضي شبه المنحدرة . ج) في حالة عدم زيادة المســافة بين المصارف يمكن تخفيض قيم أقطار مواسير الصرف المستخدمة بمقدار 50 %، د) يمكن امتداد مواسير المصارف الحقلية إلى أي مدى إذا سمحت انحــدارات الأرض مع الأخذ فــي الاعتبار أقطار وأطوال وسعــة هذه المواسير .يؤدى استخدام هذه النتائج في تصــميم وتنفيــذ شبكات الصرف المغطى إلى توفير ظروف اقتصادية جيدة للدول الأفريقية تساهم في إدخــال نظم الصرف بها .

On-Farm Water Management in Rice Fields Under Conventional and Modified Drainage Laterals Concepts

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ABSTRACT

Two field experiments were conducted at Sakha Agric. Res. Station Farm during the two successive rice seasons 2000 and 2001. Split-split-split plot design was used. Varieties occupied the main plot, Giza 177 and 178, drainage laterals system were replaced the sub plot, in two individual fields; one established with controlled valve of drainage lateral and the other without valves, methods of land levelling were assigned to sub-sub plot (Dry and wet levelling) and irrigation intervals every 4 and 6 days were the sub-sub-sub plot. It was noticed that the control valve of drainage lateral increased rice grain yield by 0.4 ton/fed. and saved irrigation water applied by 8.2% compared to conventional drainage lateral (without valve). The results indicate that the highest percentage of water losses were (54.92 and 56.01%) achieved with dry levelling and irrigation intervals every 4 days under conventional drainage lateral (without valve) for rice varieties (Giza 177 and 178), respectively. It could be concluded that Giza 178 variety, dry levelling, control valve of drainage lateral and irrigation intervals every 4 days were the best combination for On-farm water management in rice fields.

Key Words: Rice yield, Modified Drainage, Land levelling, Irrigation Intervals.

INTRODUCTION

One of the reasons for the very high water requirements for rice is the presence of the subsurface drainage system. The blocking of drain outlets is a general practice to prevent water losses and to restrict large amounts of irrigation water additions to compensate these losses. The constraint to this is that it requires that all farmers served by the collector drain must agree to grow rice at the same time. Farmers who are growing rice often block the nearest collector drain in the nearest manhole, this affects all of the neighbors upstream of the blocked section of the collectors, and causes serious problems for farmers growing cotton and maize. This drew the attention of many investigators to study the effect of drainage systems on rice crop. Abd El-Dayem et al (1987) introduced a closing device led to overcome the problem of salt accumulation as well as avoiding the adverse effect on crop yield. Some workers found that the total irrigation gift with a modified drainage system varied between 3020 and 6500

m^3/fed. with an average 4400 m^3/fed. Thus, saving of 2940 m^3/fed. (40%) of irrigation water can be achieved on using a modified system (Technical Report No.48, 1986). In this concern, EL-Mowelhi et al (1995) found that , rice grain yield significantly increased by closing the drains over opening the drains.Also, there are many ways to save irrigation water such as methods of land levelling and irrigation intervals. Saffan (1975) found that the grain yield of rice in wet levelling soil was reduced by 8-12% compared with untreated soil. Ibrahem (1981) found that zero-tillage treatment gave the highest yield than reduced tillage and wet-levelling treatments. Ramadan (1992) concluded that dry levelling treatment recorded higher values in yield and water requirements than puddling. Concerning irrigation intervals, the 4 day treatment received the highest amount of irrigation water followed by the 6 day irrigation intervals,(Mahrous et .al, 1984) . Also, Saied et al (1995) found that watering at 4 days interval treatment recorded a significant increase for rice yield over the other treatments.

This work is aimed to evaluate the lateral control valve under On-farm water management practices in rice fields.

MATERIALS AND METHODS

Two field experiments were conducted at Sakha Agric. Res. Station Farm during the two successive rice seasons 2000 and 2001. The experimental area was clayey and non-saline, non-alkaline soil.

The experimental design was split- split- split plot design. The plot size was 40 m width x 100 m length. The main plots were assigned to rice varieties, sub plots to drainage laterals system, sub- sub plots to methods of land levelling and sub- sub-sub plots to irrigation intervals.

The Treatments were as follows:

1- Rice varieties (V)

1.1. Giza 177

1.2. Giza 178

2- Drainage lateral system (D), which were established in separated fields.

2.1.Without control valves (C)

2.2. with control valve (M), as shown in photo(1)

3- Methods of Land levelling (L)

3.1 Dry levelling(l)

3.2. Wet levelling (P)

4- Irrigation intervals (I)

4.1.Conventional (I1) is increasing water head every 4 days to reach a head of 8 cm depth.

4.2 Recommended (I2) is increasing water head every 6 days to reach a head of 8 cm depth.

Photo (1): Lateral Control Valve

Nurseries were established on May 21 in both seasons and varieties were transplanted on June 24 in both seasons. Both experiments had received the recommended doses of P as superphosphate (15.5 P_2O_5) and N as urea (46%N). As for the other agronomic practices all the recommendations were followed. Meteorological data at Sakha station during the two seasons had been daily recorded and their mean monthly values are presented in Table (1).

Table (1) Meteorological data at Sakha station during the two seasons.

Months	First season 2000							Second season 2001						
	Temp (c^0)			Relative humidity %	Wind speed Km/ day	Solar radiation Cal/cm²/day	Evaporation Cm/ day	Temp. (c^0)			Relative humidity %	Wind speed Km/ day	Solar radiation cal./cm2/day	Evaporation Cm/ day
	Max.	Min	Mean					Max.	Min	Mean				
Jun	31.2	18.2	24.7	57.7	172.3	566.4	0.69	32.2	20.2	26.2	56.1	124	590.7	0.549
Jul.	31.6	21.3	26.45	69.8	143.5	575.2	0.81	32.6	21.5	27.5	68.3	91.7	591.5	0.71
Aug	32.2	23.1	24.65	69.5	96.6	588.6	0.71	33.9	21.6	27.75	68.0	110.9	604.3	0.713
Sep.	32.2	18.8	25.5	62.4	83.4	586.5	0.61	31.3	18.6	24.95	66.53	103.03	567.4	0.61

Water measurements:

1. water balance of a given rice area can be defined as follows (Goor Van de, Zjlstra, 1968):

Qir = Qsd + Qud + ETc – DWsi + DWs where:

Qir: irrigation water delivered to each plot was measured and controlled by using the cut-throat flume, 30 x 90 cm (Early, 1975),mm/period.

Qsd: surface drainage outflow in mm/period

Qud: subsurface drainage outflow in mm/period

DWsi: increase (+) or decrease (-) in the volume of the standing water layer between two observations data (mm/period).

DWs : increase (+) or decrease (-) in the total moisture content between the commencement of soil preparation of the nurseries and the rice harvest (mm/period).

2. Evapotranspiration(Eto) was calculated by modified Penman equation according to (Doorenbos and Pruitt, 1977).

   ETo = C[W.Rn + (1-w).f (u). (ea-ed)]

   Where :

ETo :	reference crop evapotranspiration in mm/day
W:	temperature – related to weighing factor.
Rn:	net radiation in equivalent evaporation
F(u):	wind speed related function.
(ea-ed):	difference between the saturation vapour pressure of the air (both in mbar).
C:	adjustment factor to compensate for the effect of day and night weather conditions.

2.1. Actual Evapotranspiration (ETc) : was computed according to the following equation :

$ETc = ETo \times KC$

Where :

KC : crop coefficient of rice.

3. Water utilization efficiency (WUE) : it was calculated according to the following equation:

WUE = Rice grain yield (kg/fed.)/Irrigation water delivered (m^3/fed.) According to Abd El-Rasool (1971).

The following characters were studied: Rice grain yield (ton/fed.), straw yield (ton/fed.), 1000 grain weight, panicle length (cm), and plant height (cm). All data were statistically analyzed according to Snedcor and Cochran (1967).

RESULTS AND DISCUSSIONS

1. Rice yield and its components

The mean values of rice yield and its components as affected by different treatments in the two growing seasons are presented in Table (2 and 3).

Effect of varieties:

It is clear from Tables (2 and 3) that there was a significant effect of varieties on rice grain and straw yield in the two growing seasons. Concerning the yield components, there was a significant effect of varieties on 1000 grain weight, panicle length and plant height in the first season. On the other hand, 1000-grain weight and plant height were not significantly affected in the second season. The highest mean values of rice grain yield (3.77 and 3.8 ton/fed.) were obtained under Giza 178 variety in the two growing seasons respectively. Whereas the lowest values (3.31 and 3.3 ton/fed.) under Giza 177 variety for both seasons. It is evident that Giza 178 surpassed the Giza 177 in increasing rice grain yield by 12.2 and 13.16% in the two growing seasons respectively.

Effect of drainage lateral system:

Rice yield and its components under drainage treatments are shown in Tables (2 and 3). Data indicated that rice yield significantly increased due to blocking drainage lateral with control valves. With regard to 1000-grain weight, panicle length and plant height, data reveal that all the mean

values of these characters were significantly increased due to blocking drainage lateral over the conventional drainage in the first season. However in the second season, these characters were not significantly affected. The average rice grain yields were 3.32 and 3.76 ton/fed. for conventional and modified drainage lateral, respectively, where the increment was 11.7% in the first season. While in the second season the values were 3.33 and 3.77 ton/fed. for conventional and modified drainage lateral, where the increment was 11.67%. The lower yield in the conventional drainage lateral as a result of soil deteriorations induced by the permanent absence of adequate drainage. Also a modified system for drainage lateral in rice fields can satisfy the need of drain closure. Nevertheless, drainage realized more favorable conditions since harmful substances are removed and fresh oxygen is provided. This point of view supported by the work of EL-Mowelhi et al (1995).

Effect of land levelling methods:

Data in Tables (2 and 3) indicate that methods of land levelling had a significant effect on rice yield (grain and straw). Also, land levelling had a significant effect on all characters studied in the first season. Whereas in the second season these characters were not significantly affected except plant height. Also, data reveal that dry levelling increased rice grain yield by 4.96 and 6.01% compared to wet levelling in the two growing seasons respectively. Thus, the grain yield was reduced with increasing the compaction of soil. Similar results were obtained by Saffan (1975), Ibrahem (1981), and Ramadan (1992).

Effect of irrigation intervals:

Data in Tables (2 and 3) showed that rice yield and its components were significantly affected by the irrigation intervals except the plant height in the second season. Irrigation intervals every 4 days achieved the highest values for rice grain and straw yields in the two growing seasons compared to irrigation interval every 6 days. This trend was reported by Saied et al (1995).

Effect of interaction:

The interaction effect between varieties x drainage lateral system on rice grain yield was significant in the first season. While in the second season, there was interaction between varieties x drainage, varieties x land levelling, varieties x irrigation intervals and land levelling x

irrigation intervals. Concerning the straw yield and yield components, there was significant interaction effect due to different treatments in the first and second seasons, respectively.

It can be concluded that, blocking drainage lateral with control valve and applied some improved irrigation practices increased the rice grain yield by about 0.4 ton/fed.

2.Rice water balance:

Mean values of water balance in rice are presented in Table (4) and Fig. (1 and 2). The water requirement of rice is the summation of actual evapotranspiration and water losses.

It has been noticed that Giza 177 variety received less amount of irrigation water as compared to Giza 178 variety. On the other hand dry levelling and irrigation intervals every 4 days received the highest amount of irrigation water applied (5953.5 and 6238.68 m^3/fed.) with two varieties, respectively under conventional drainage. The corresponding values under modified drainage were (5133.24 and 5334.0 m^3/fed.) under two varieties and the same treatments. While the lowest values were achieved with wet levelling and irrigation intervals every 6 days for both drainage system. Concerning the actual evapotranspiration, data show that there is no big differences between the different treatments under each variety because of they are located in the same meteorological conditions. Respecting to water losses, during most of the two growing season under prolonged ponded water, it was determined from drain outflow calculations.

Data presented in Table (4) indicate that the highest percentage of water losses (54.92 and 56.01%) were achieved with land levelling and irrigation intervals every 4 days under conventional drainage with Giza 177 and 178 varieties respectively. While the lowest percentage of losses (46.28 and 44.62%) were obtained with wet levelling and irrigation intervals either every 4 days or 6 days under modified drainage. The most proper explanation for these results is that there is no compaction in dry levelling, so percolation losses were higher in dry levelling treatment than wet levelling. Data also indicate that, modified drainage saved irrigation water by 7.43 and 8.92% under Giza 177 and 178 respectively. These results are in agreement with those obtained by Ramadan, 1992 and El-Mowelhi et al, 1995.

3. Water utilization efficiency:

Water utilization efficiency is defined as kg of rice grain produced per one cubic meter of water applied. The values of water utilization efficiency can be increased either by increasing crop productivity or by decreasing water losses.

Table (5) shows the values of water utilization efficiency as influenced by different treatments throughout the two seasons of investigation. It was noticed that the blocking drainage lateral with control valve, dry levelling and irrigation intervals every 4 days under Giza 177 variety achieved the highest values of water utilization efficiency (0.67 and 0.68 kg/m^3 of water applied) in the two growing seasons respectively. While the corresponding values with Giza 178 variety were (0.81 and 0.78 kg/m^3) in the two growing seasons respectively, for the stated treatments.

In contrary to this, the conventional drainage lateral (without valve), dry levelling and irrigation intervals every 4 days under Giza 177 variety recorded the lowest values of water utilization efficiency (0.54 and 0.54 kg/m^3) in the two growing seasons respectively. While under Giza 178 variety, the corresponding values were (0.56 and 0.55 kg/m^3) in the two growing seasons respectively. These findings may be attributed to that the lateral control valves recorded the highest grain yield and received less amount of irrigation water compared to the other treatments. These results are in agreement with those obtained by Abd EL-Dayem et al (1987), EL-Mowelhi et al (1995) and Saied et al (1995).

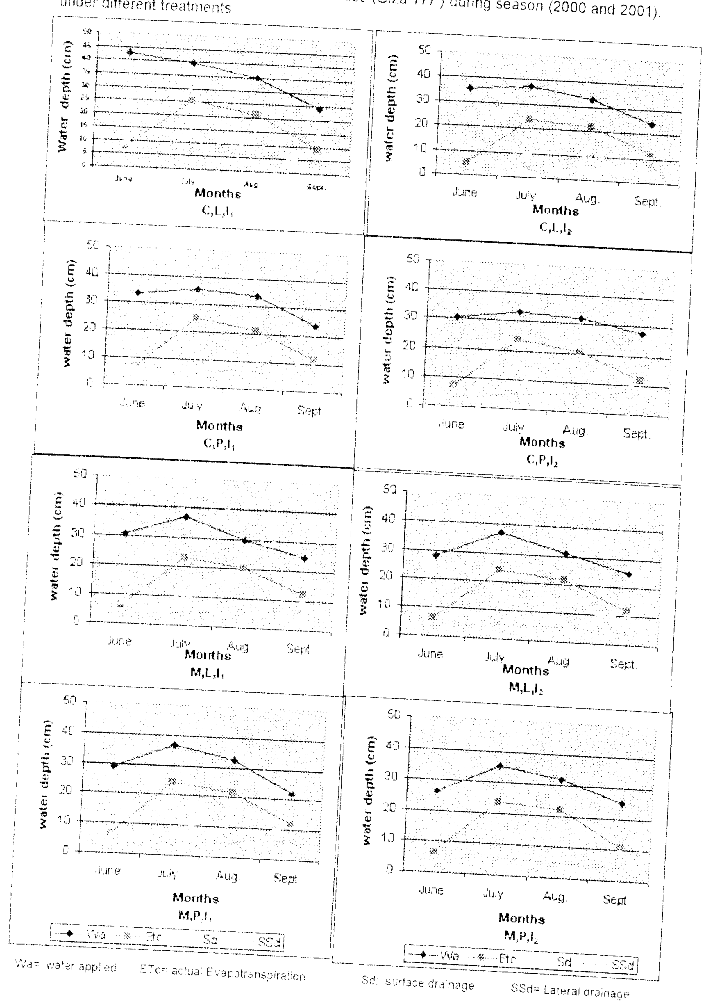
Table (2): Effect of different treatments on rice yield and its components, growing season, 2000

Treatments	Grain yield (ton/fed.)	Straw yield (ton/fed.)	1000-grain weight (g)	Panicle length cm	Plant height (cm)
Varieties (v)					
Giza 177	3.30	4.722	20.4	19.2	99.375
Giza 178	3.80	4.852	20.6	18.5	98.33
F. test	*	*	Ns	*	Ns
L.S.D 0.05	0.185	0.98		0.8	
0.01	0.227	-	-	-	-
Drainage Lateral system (D)					
Conventional (C)	3.33	5.128	27.7	19.5	98.45
Modified (M)	3.77	5.245	27.3	20.1	99.25
F test	**	*	ns	ns	Ns
L.S.D 0.05	0.139	0.96	-	-	-
0.01	0.191	-	-	-	-
Land levelling (L)	-	-	-	-	-
Dry levelling (l)	3.66	5.159	20.4	20.5	97.36
Wet levelling(P)	3.44	5.215	20.4	21.2	100.25
F. test	**	ns	ns	ns	*
L. S D. 0.05	0.140	-	-	-	1.5
0.01	0.191		-	-	-
Irrigation intervals (I)					
4 days(I_1)	3.61	5.433	27.3	19.5	98.66
6 days(I_2)	3.50	4.941	28.4	20.4	99.04
F test	**	**	*	*	Ns
L .S D. 0.05	0.145	0.29	0.6	0.9	-
0.01	0.194	0.415	-	-	-
Interactions					
F test					
V x D	**	*	*	*	*
V x L	*	*	*	*	*
V x I	ns	*	*	*	*
D x L	*	*	*	*	*
D x I	ns	*	*	*	*
L x I	*	*	*	*	*
D x L x I	*	*	*	*	*
V x D x L x I	ns	*	*	*	*

Table (3): Effect of different treatments on rice yield and its components, growing season, 2001

Treatments	*Grain yield (ton/fed.)*	*Straw yield (ton/fed.)*	*1000-grain weight (g)*	*Panicle length (cm)*	*Plant height (cm)*
Varieties (v)					
Giza 177	3.31	5.123	27.8	19.5	98.5
Giza 178	3.77	4.852	25.5	20.1	93 2
F . test	*	*	*	*	*
L S.D 0.05	0.35	0.235	1.5	1.1	2.5
0.01	-	-	-	-	-
Drainage Lateral system (D)					
Conventional (C)	3.32	4.15	29.3	21.2	95 4
Modified (M)	3.76	3.85	28.1	20.5	96.2
F . test	**	*	*	*	*
LS.D 0.05	0.131	0.125	0.85	0.7	0.65
0.01	0.181	-	-	-	-
Land levelling (L)					
Dry levelling(l)	3.63	4.1	25.6	20.1	95.2
Wet levelling(P)	3.45	4.26	28.4	21.5	97.2
F. test	**	Ns	*	*	*
L .S.D. 0.05	0.134	-	1.1	0.8	1.5
0.01	0.183	-	-	-	-
Irrigation intervals (I)					
4 days(I_1)	3 60	39 56	27.1	20.3	95.6
6 days(I_2)	3.48	4.15	28.4	21.8	96.8
F .test	**	*	*	*	*
L .S.D. 0.05	0.108	0.235	1.1	0.9	1 02
0.01	0.145	-	-	-	-
Interactions					
F test					
V x D	**	*	*	*	*
V x L	ns	*	*	*	*
V x I	*	*	*	*	*
D x L	ns	*	*	*	*
D x I	*	*	*	*	*
L x I	ns	*	*	*	*
D x L x I	*	*	*	*	*
V x D x L x I	ns	*	*	*	ns

Fig (1) Mean values of water balance for Rice (Giza 177) during season (2000 and 2001). under different treatments



Wa= water applied ETc= actual Evapotranspiration Sd: surface drainage SSd= Lateral drainage

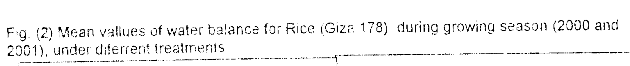
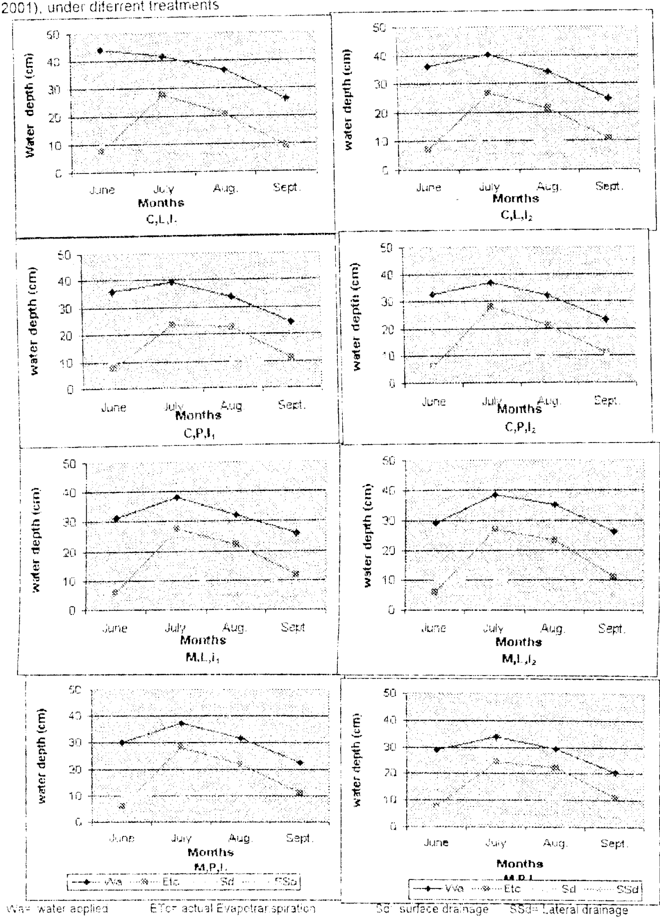


Fig. (2) Mean values of water balance for Rice (Giza 178) during growing season (2000 and 2001), under diferrent treatments



Wa= water applied ETc= actual Evapotranspiration Sd= surface drainage SSd= Lateral drainage

Table (5) : Water utilization efficiency (kg/m^3) for rice as affected by drainage system, methods of land levelling and irrigation intervals during 2000 and 2001 growing seasons

Treatments				*Season 2000*		*Season 2001*		
Varieties	*Drainage system*	*Land levelling*	*Irrigation intervals.*	*Amount of water applied (m^3/fed.)*	*Rice grain yield (kg/fed.)*	*Water utilization efficiency (kg/m^3)*	*Rice grain yield (kg/fed.)*	*Water utilization efficiency (kg/m^3)*
Giza 177	C	l	I_1	6077.5	3270	0.54	3271	0.54
			I_2	5739.82	3180	0.55	3200	0.56
		p	I_1	5550.4	3160	0.57	3120	0.56
			I_2	5474.8	3100	0.57	3060	0.56
	M	l	I_1	5382.4	3600	0.67	3640	0.68
			I_2	5348.8	3390	0.63	3440	0.64
		p	I_1	5315.2	3360	0.63	3420	0.64
			I_2	5243.8	3350	0.64	3310	0.63
Giza 178	C	l	I_1	6487	3600	0.56	3580	0.55
			I_2	5932.6	3530	0.60	3510	0.59
		p	I_1	5844.4	3450	0.59	3390	0.58
			I_2	5512.6	3370	0.61	3360	0.61
	M	l	I_1	5584	4510	0.81	4330	0.78
			I_2	5428.6	4190	0.77	4100	0.76
		p	I_1	5328.6	3900	0.73	3970	0.74
			I_2	5248.84	3860	0.74	3890	0.74

Table (4): Mean values of irrigation water applied (m^3/fed.), actual evapotranspiration and water losses(m^3/fed.) as affected by different treatments.

Treatments			Conventional drainage(C)				Modified drainage (M)				
Varieties	Land levelling	Irrigation intervals	Water applied m^3/fed.	ETc m^3/fed.	Water losses m^3/fed.	Water losses %	Water applied m^3/fed.	ETC m^3/fed.	Water losses m^3/fed.	Water losses %	Water saving %
Giza 177	Dry (I)	I_1	5953.2	2684.22	3269.7	54.92	5133.24	2615.34	2517.9	49.05	13.78
		I_2	5488.56	2660.28	2828.28	51.53	5098.8	2703.12	2395.7	46.99	7.10
	Mean		5721.03	2672.25	3048.99	53.22	5116.02	2659.23	2456.8	48.02	10.44
	Wet (p)	I_1	5298.3	2717.4	2580.9	48.71	5065.2	2721.18	2344.02	46.28	4.4
		I_2	5224.38	2648.1	2576.28	49.31	4993.8	2660.28	2333.94	46.74	4.41
	Mean		5261.34	2682.75	2578.59	49.01	5029.5	2690.73	2338.98	46.51	4.41
Giza 178	Dry (I)	I_1	6238.68	2744.28	3494.4	56.01	5334.0	2828.28	2505.72	46.98	14.5
		I_2	5683.02	2770.32	2912.7	51.25	5260.5	2843.4	2417.1	45.95	7.43
	Mean		5960.85	2757.3	3203.55	53.63	5297.25	2835.84	2461.41	46.47	10.97
	Wet (p)	I_1	5595.24	2737.98	2857.26	51.07	5105.52	2827.44	2278.08	44.62	8.75
		I_2	5260.5	2783.76	2476.32	47.07	4998.84	2768.22	2230.62	44.62	4.97
	Mean		5427.87	2760.87	2666.79	49.07	5052.18	2797.83	2254.32	44.62	6.86

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الملخص العربي

إدارة المياه في حقول الأرز تحت ظروف أساليب معدلة لحقليات الصرف المغطي

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أقيمت تجربتين حقليتين بمحطة البحوث الزراعية بسخا في موسمي زراعة الأرز ٢٠٠٠، ٢٠٠١ استخدم في هذه التجارب نظام القطع المنشقة ثلاث مرات بحيث وضعت الأصناف جيزة ١٧٧ ، ١٧٨ في القطع الرئيسية ، نظم حقليات الصرف المغطي في القطع المنشقة الأولى (محابس ، بدون محابس) ، ومثلت التسوية (تسوية جافة بالليزر ، تسوية مبتلة) القطع المنشقة الثانية بينما وضعت فترات الري (كل ٤ أيام ، ٦ أيام) في القطع المنشقة الثالثة .

وقد أوضحت النتائج أن غلق حقليات الصرف المغطى بمحابس خاصة آدت إلى زيادة معنوية في محصول حبوب الأرز بنسبة ٠,٤ طن/ فدان كما آدت إلى توفير ٨,٢ % من كمية مياه الري المضافة . كما دلت النتائج المتحصل عليها أن اعلي نسبة من فواقد مياه الري ٥٤,٩٢ %، ٥٦,٠١ % تحققت مع التسوية الجافة والري كل ٤ أيام وتحت نظام حقليات الصرف التقليدي (بدون محابس) لكل من صنفي الأرز جيزة ١٧٧، ١٧٨ علي الترتيب.

ويمكن استنتاج ان التحكم في حقليات الصرف المغطى بهذه المحابس والتسوية الجافة والري كل ٤ أيام تؤدى إلى تعظيم العائد من وحدة مياه الري المضافة .

Evaluation of Mole Drain Practices Under Heavy Clay Salt Affected Soils at North Delta

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ABSTRACT

Four demonstration fields (compacted heavy clay, slightly saline, moderately saline and highly saline soil) were selected to evaluate mole spacing (3,6,9 and 12 m) , mole design (net or parallel) , filling materials (sand or gypsum) and gypsum application methods(surface, subsurface or moling). The indicators to be studied are EC, SAR and basic infiltration rate of soil and productivity of some crops (berseem, sorghum, rice, sugar beet, wheat and barley).

In majority of cases, decreasing the mole spacing from 12 to 3 m clearly increased basic infiltration rate of heavy clay soil, obviously promoted salt leaching from soil profile and significantly increased the productivity of berseem and sorghum.

The net moles were better than parallel moles for berseem while parallel moles were better for rice .

Sand filled moles were superior to gypsum moles and both of them were better than unfilled moles in increasing basic infiltration rate and promoting salt leaching and consequently increasing the yield of rice and berseem. Also, sandy moles were more effective for reclaiming high saline soil and achieved higher yield of wheat and barley.

Addition of gypsum in mole drains or subsurface application achieved better properties of salt affected soil and produced higher yield of sugar beet. Gypsum rate of 8 tons/fed was slightly better than 4 tons/fed.

Economic analysis showed that sandy moles with parallel design and 3-m spacing achieved the highest net farmer income with different crops. Finally moling as a method of gypsum application is profitable method and increased the net farmer income with sugar beet

Key words: mole drain, heavy clay soil, crop productivity, soil improvement and economic analysis

INTRODUCTION

Heavy clayey salt-affected soils with low permeability are not mostly proper for crop production. Therefore, efficient aeration and good drainage system are important factors for accelerating salt leaching and developing soil properties to be proper for crop production. In Egypt, there are about 2 million feddans of heavy textured soils, most of them concentrated in Nile Delta, which suffer from the presence of dense layers and clay pan (Hamdi et al, 1968). The prime requirement in these soils is the water to flow fast and uniformly from the surface layers into the drain. Hence, subsurface drainage (0.6m depth in clay soils) may be adequate to permit the necessary leaching and to hold water table to a sufficient depth, preventing the upward movement of salty capillary water

from reaching crop root zone (Richard, 1990). Mole drain is considered as efficient, economic and successful subsurface drainage method (sukwiwet, 1970) and as a temporery subsurface drainage system for reclaiming saline and saline alkaline soils (spoor, 1993). However, inserting some filling materials in the mole elongates its life and increases its effectiveness. Therefore, Bakr and EL-Attar (1972) and EL-Sabry et al (1992) reported that sand filled moles were more effective in salt leaching than unfilled moles. On the other hand, the net moles were found to be more effective in salt leaching than parallel ones and consequently in increasing its productivity (AbouEL-Soud et al, 1996, Abo soliman, et al, 1996 and EL- Abaseri et al, 1996). The common practices should be applied to improve the chemical and physical properties of salt affected soil and to increase its productivity are deep ploughing or mole drainage and addition of some soil amendments such as gypsum in presence of good drainage system (EL-Gebaly, 1972, Talhe et al, 1979, and Abo Solmian et al, 1996). Evaluation of some management practies for salt affected heavy clay soil is objected in this study. These practices are sand or gypsum filled or unfilled moles in two design (parallel or net moles) with four spacing (3,6 , 9 and 12 m) as well as gypsum application methods.

MATERIALS AND METHODS

Field experiments were carried out in four demonstration fields different in their properties to evaluate moling methods as a tool for impoving crop productivity and properties of salt affected clay soil. Different treatments are spacing and design, filling material and gypsum application methods. The treatments of each demonstration field could be illustrated as follows:

1- Field No 1:

An area of 20 feddan of clayey compacted soil was selected at Basune District, Gharbia Governorate, to evaluate four mole spacing (3,6,9 and 12 m) with or without sand to be compared with the control (without mole). Crop rotations was berseem followed by sorghum in two successive seasons.

2- Field No 2:

This field was 23 fed allocated at Sakha Farm, and the soil was clayey salt affected soil (ECe = 8.93 dSm^{-1} and ESP = 18.27%).This field was selected to evaluate the mole design (parallel or net) as well as the back filling materials (sand or gypsum) with 3m spacing and 50 cm depth. The cultivated crops were berseem followed by rice.

3- Field No 3 :

This site was selected in the graduated area of EL-Hamol District,

Kafi El-Sheikh, North Delta. The area was about 30 fed of clayey saline soil in three sites (10 fed for each). The first site was saline soil (ECe =9 dSm^{-1}) and cultivated by wheat. The second site was highly saline soil (ECe=31 dSm^{-1}) and cultivated by wheat. The third site was very high saline soil (ECe=50 dSm^{-1}) and cultivated by barley. This experiment was conducted to compare subsoiling and sand filled mole with the control (without mole).

4- *Field No 4:*

About 7 fed was selected at Sakha Agric. Res Station representing the salt affected clay soil at North Delta. This field was to study gypsum application methods (surface, subsurface and gypsum back filled moles) with 3 rates (0,4, and 8 ton/fed) on wheat and barley yield and some soil properties (ECe ,SARe and basic infiltration rate).

Soil samples were collected from each site before planting and after harvesting. Chemical analysis was done according to Black (1965). Infiltration rate was determined for each site before and after harvesting according to Garcia (1978).

RESULTS AND DISCUSSION

1- *Mole spacing:*

1-1 Effect of mole spacing on basic infiltration rate:

Data show that basic infiltration rate (IR) was increased with moling especially with narrower spacing. The less spacing of mole, the more increasing was the basic infiltration rate. This result is in agreement with those obtained by El-Sabry et al (1992) and Abou El-Soud et al (1996).

1-2 Effect of mole spacing on soil salinity:

Data also show a reduction in total soluble salts (ECe) and SAR according to moling practice comparing to the control. The reduction was more pronounced as the mole space decreased.

1-3 Effect of mole spacing on the yield:

Fresh weight values of berseem and sorghum as affected by mole spacing are presented in Table (1). Generally, moling (at any spacing) led to significant increase of crop yields (berseem and sorghum) compare to the control (without moling). 3m spacing surpassed the other spacings with yield of 18.46 and 20.0 tons/fed for berseem and surghun, respectively. The yield of both crops could be descendingly ranked according to the mole spacing as follows:

3m > 6 m > 9 m > 12m

This result may be attributed to that moiling practice removed the excess free water and salts from soil profile. These results are corresponding to those reported by Baily(1978) ,Osteabeen and wind (1978) , sejka et al.(1990) and Abou El-Soud et al (1996)

Table (1) Effect of sandy mole spacing on yield of berseem and sorghum and some properties of heavy clay soil.

Mole spacing	Crop	Yield ton/fed	ECe dSm^{-1}	SAR	Basic IR mm/hr
Control	Berseem	10.81	3.31	4.10	10.1
3		18.46	1.82	2.82	50.5
6		17.42	2.19	3.52	32.3
9		15.67	2.25	3.02	20.5
12		12.00	2.70	3.60	20.0
Control	Sorghum	11.96	3.46	5.81	13.2
3		20.00	2.07	5.75	52.3
6		18.78	2.30	6.33	36.4
9		16.67	2.56	5.56	22.5
12		14.15	2.80	6.44	19.3

1- Mole design:

2-1 - Effect of mole design on basic infiltration rate:

Data show that net design was slightly better than parallel design in increasing basic IR in case of rice and berseem crops. Moreover sandy mole increased basic IR more than gypsum mole or unfilled mole with rice or berseem These results are in agreement with those obtained by EL-Sabry et al. (1992) and Gazia et al. (1996).

2-2- Effect of mole design on soil salinity:

Data show that parallel design decreased ECe and increased SARe compared to net design under rice conditions. While the opposite trend was noticed in case of berseem crop, since net design decreased ECe and increased SARe compared to parallel design. These results may be due to that rice crop require more amount of irrigation water which leach more amount of salts and parallel design helps in this case. Also, it was noticed that sandy mole surpassed gypsum mole in leaching soluble salts with rice crop, while gypsum mole leached more salts in case of berseem crop. Contrarily, gypsum mole surpassed sandy mole in decreasing SARe with rice and berseem.

2-3- Effect of mole design on rice and berseem yields:

Table (2) shows the yield of rice and berseem as affected by mole design (parallel and net) and back filling material (sand and gypsum) as will as the control (without filling). Data show that parallel design led to increase the rice yield compared to net design, while berseem yield was increased in case of net design more than parallel design. Also data show that sandy mole surpassed gypsum mole for both crops, and both of them surpassed unfilled mole.

3- Mole methods under different levels of soil salinity:

In this field , sandy filled mole was compared to unfilled mole and untreated soil with wheat and barley crops under three soil salinity levels (saline , high saline and very high saline) as shown in Table (3)

3-1- Effect of mole practice on basic infiltration rate:

The value of basic infiltration rate differs greatly with different soil management and soil salinity levels. It could be observed that the lowest values of basic infiltration rate were found with very high salinity of soil in site No.3 (1.5-2.3 mm/hr) while the highest values were recorded with saline soil in site No 1 (5-5.8 mm/hr). Under the three levels of soil salinity, construction of mole drain improved basic infiltration rate better than in untreated soil. Also, mole drain filled by sand was more effective than the unfilled mole since it recorded higher values of basic infiltration rate. This finding may be attributed to that filling meterial protects the mole from collapsing to be more efficient in long time.

Table (2): Effect of mole desgin and back filling material on rice and berseem crop yields and some properties of heavy clay soils.

Crop	Moiling design	Back filling material	Yield (ton/fed)	ECe dSm^{-1}	SAR	Basic IR mm/hr
Rice	Parallel	without	3.67	5.91	8.56	7.0
		sand	4.16	4.66	8.11	9.0
		gypsum	4.05	4.95	7.01	8.0
		Mean	3.95	5.17	7.89	8.0
	Net	Without	3.16	5.93	8.14	8.0
		sand	3.95	4.76	7.91	9.0
		gypsum	3.80	5.14	7.05	9.0
		Mean	3.64	5.28	7.70	8.67
Berseem	Parallel	Without	19.5	7.48	9.44	9.0
		Sand	23.2	7.39	10.13	12.0
		gypsum	21.0	6.54	8.19	10.0
		Mean	21.23	7.14	9.25	10.33
	Net	Without	20.5	7.18	9.11	10.0
		sand	24.0	6.54	9.97	12.0
		gypsum	22.6	6.58	8.42	11.0
		Mean	22.37	6.77	9.17	11.0

3-2 Effect of mole practice on soil salinity

It could be observed from the data that sandy back filled mole was better than the unfilled mole in the three sites since it gave lower values of both ECe and SARe especially in high saline soil. Also, filled and unfilled moles, were obviously better than untreated soil because both of them were more efficient in salt leaching in all sites, This trend is in somewhat appropriated with the trend of the infiltvation rate that recorded with the same treatments, since the higher the basic infiltration rate, the lower were the ECe and SARe values.

3-3- Effect of mole practice on yield of wheat and barle:

Wheat plant is moderately tolerant to salinity while barley plant is tolerant to salinity, so wheat was selected to be planted in the 1st and 2nd sites (saline and high saline soil) while barley was planted in the 3rd site (very high saline soil). In general, the yield of wheat and barley was relatively low especially in the 2nd and 3rd sites. The yield of both crops was posotively affected by mole treatments. The highest yields of wheat and barley were given with sand filled moles followed by unfilled moles while untreated soil produced very low yield of both crops. It could be observed that the yields of wheat and berley are completely related to the values of ECe ,SARe and basic infiltration rate as shown in Table (3).

Table (3) Effect of mole method on crop yield and some soil properties under different levels of soil salinity;

Site No.	Filling materials	Crop	Yield kg/fed.	ECe dSm^{-1}	SARe	Basic IR mm/hr
1 (saline soil)	Control Without Sand	Wheat	382 937.5 1380	15 10 9	11.3 8.8 9.5	5.0 5.5 5.8
2 (highly saline soil)	Control Without Sand	Wheat	135 337.5 385	36.5 28.0 24.0	29 25 19	2.5 2.8 3.0
3 (very high saline soil)	Control Without Sand	barley	90 510 735	42.0 31.5 36.0	33.5 30.0 26.0	1.5 2.0 2.3

4- gypsum application methods and rates:

Gypsum application rates and methods were evaluated to know their effects on properties and productivity of salt effected clay soils. This soil needs chemical amendment and subsurface tillage to be improved. Gypsum is cheep amendment and subsoiling is good way for subsurface tillage, so, it is used in this demonstration field.

4-1 Effect of gypsum on basic infiltration rate:

Data illustrated in Table (4) indicated that the application of gypsum as a filling material in mole drain was slightly effective than other methods of application in improving soil infiltration characteristic where it gave the highest values of basic infiltration rate (4.1 mm/hr). The surface application of gypsum was less effective method on basic infiltration rate followed by subsurface application (3.3 and 3.9 mm/hr, respectively). Gypsum rates clearly affected the basic infiltration rate and

its values with the control (without gypsum), 4 ton/fed. and 8 ton/fed were 2.6, 4.1 and 4.6 mm/hr ,respectively.

4-2 Effect of gypsum on soil salinity:

Values of ECe and SARe with subsurface and moling application of gypsum were slightly different but their values were clearly higher than that with surface application. The values of ECe and SARe are reversly related to values of basic infiltration rate. Concerning gypsum application rates, data showed the superiority of 8 ton/fed over the control and 4 ton/fed since it recorded the lowest values of ECe and SARe (4.49 dSm^{-1} and 8.43,respectively)

4-3 Effect of gypsum on sugar beet yield:

The root yield of sugar beet was significantly affected by gypsum application methods and rates. Concerning the methods of gypsum application, the data indicate that the moling application of gypsum gave the highest root yield (18.25 ton/fed) while the lowest value of root yield was recorded with the control (16.25 ton/fed). In regarding to the application rate, 8 ton gypsum/fed gave the highest root yield (17.75 ton/fed) while the lowest root yield (16.68 ton/fed) was given by untreated soil. The values of root yield as affected by gypsum application rates and methods are in somewhat related to the trend of ECe, SARe and basic infiltration rate. The superiority of application of gypsum in mole can be explained on the basis that this method includes chemical solution of alkalinity by gypsum and subsurface tillage of soil by moiling practice and this, consequently increased the effectiveness of gypsum.

Table (4) Effect of the methods and rates of gypsum application on yield of suger beet, ECe, and basic infiltration rate.

Treatment	Yield		ECe	SARe	Basic IR mm/hr
	Root yield ton/fed	Sucrose			
Surface	16.25	18.04	6.69	10.24	3.3
Sub-surface	16.83	18.38	4.34	8.34	3.9
Moling	18.25	18.20	4.84	9.52	4.1
Control (without Gyp.)	16.68	18.18	6.86	10.35	2.6
4 ton/fed	17.00	18.29	4.52	9.32	4.1
8 ton/fed	17.75	18.15	4.49	8.43	4.6

Economic analysis:

Many practices could be applied to improve the chemical and physical conditions of salt affected sois in order to increase its productively, and hence increase farmer income. Deep ploughing, mole drain and addition of some amendments such as gypsum are examples of these practices. Technically, these pracices lead to improve soil conditions and increase its productivity. But it is remain to emphasize, economically, which of these practices is more profitable to the farmer. In the other words, in this manner. Economic analysis was done to determine the net farmer income increase due to investing in constructing sandy mole drains by different spaces after discounting the total mole construction cost using farm gate prices (Table 5). It is found that 3m space is more profitable to the farmer, since it returned about 766 L.E/fed. as an increase in the farmer income under berseem and sorghum rotation. Mole space of 12 m was less profitable for the farmers since it returned about143.5 L.E as increase in the income. Table (6) shows the net farmer income increase due to mole design (parallel or net) and the back filling materials (sand or gypsum). It was found that parallel mole filled with sand is the most profitable practice (net farmer income increase was 1577 L.E/fed.), under rice and berseem rotation followed by net mole filled with sand (net farmer income increase was 422 L.E/fed.). In regarding to the filling materials, it was found that mole drain without filling material increased the net farmer income, by 227 L.E/fed, during one season of wheat or barley, while sandy filled mole drain increase the net farmer income, by 374 L.E/fed. (Table 7). Concerning gypsum application, It was found that application of gypsum in mole is aprofit method of application, since it increases the net farmer income by 109 L.E/fed., while the other two methods are unprofit Also, application of 4 tons gypsum/fed is profit for the farmers since is net return was found to be 18.7 L.E/fed (Table 8).

Table (5) Net farmer's income increase due to sandy mole spacing after two seasons: (according to 2000 farm gate prices) compare to control treatment

Mole spacing (m)	Total cost/f(L.E)	Income increase L.E			Net farmer income increase fed/year L.E
		Berseem	Sorghum	total	
Control	-	-	-	-	-
3 m space	48.40	573.75	241.2	814.95	766.25
6m space	24.30	495.75	204.6	700.35	676.05
9m space	16.30	364.50	141.3	505.80	489.50
12m space	11.40	89.25	65.7	154.90	143.50

Table (6): Net farmer income increase due to mole design and back filling material after two seasons (according to farm gate prices 2000).

Treatment		Total moling cost/(LE/fed)	Income increase L.E /fed.			Net farmer income increase (LE/fed/year)
Design	Filling material		Rice	Berseeem	total	
	Control	0.0	0.0	0.0	0.0	0.0
Parallel	Without	36.0	1002	237.5	1239.5	1203.5
	Sand	48.7	1296	330.0	1626.0	1577.3
	Gypsum	106.0	1230	275.0	1505.0	1399.0
Net	Without	72.0	696	262.5	958.5	886.5
	Sand	97.3	1170	350.0	1520.0	1422.7
	Gypsum	218.7	1080	315.0	1395.0	1176.3

Table (7): Net farmer income increase due to mole method with wheat and barley under different levels of soil salinity.

Site	Filling material	Total cost LE/fed	Farmer income (LE/fed)	Farmer income increase/fed	Net farmer income increases (LE/fed)
1	Control	-	255.9	-	-
	Without	36	628.1	372.2	336.2
	Sand	48.7	924.6	668.7	620.0
2	Control	-	90.5	-	-
	Without	36	226.1	135.6	99.6
	Sand	48.7	258.0	167.5	118.8
3	Control	-	60.3	-	-
	Without	36	341.7	281.4	245.4
	Sand	48.7	492.5	432.2	383.5
Mean	Control	-	135.6	-	-
	Without	36	398.6	263.0	227.0
	sand	48.7	558.4	422.8	374.1

Table (8): Net farmer income increase due to gypsum application method and rates under sugar beet crop.

Treatment	Total cost/fed.L.E	Farmer income L.E	Farmer income increase L.E	Net farmer income increase
Control	0	1120	0	0
Surface	68.7	1137	17	(-51.7)
Sub-surface	75.3	1178.1	58.1	(-17.2)
Moiling	48.6	1277.5	157.5	108.9
0	32.0	1167.6	47.6	15.6
4 ton/fed	51.3	1190.0	70.0	18.7
8 ton/fed	92.7	1242.5	22.5	(-70.2)

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الملخص العربي

تقيم أنفاق الصرف الزراعي في الأرضي الطينية الثقيلة المتأثرة بالاملاح في شمال الدلتا

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أقيمت تجربة حقلية في ارض ثقيلة القوام متأثرة بالأملاح في شمال الدلتا لتقييم ملائمة واقتصاديات أنفاق الرمل وطرق إضافة الجبس لتحسين الخواص الطبيعية والكيميائية وإنتاجية هذه الأراضي .

ولقد أقيمت التجارب في أربعة حقول إرشادية مع استخدام ستة محاصيل (أرز ، قمح ، شعير ، برسيم ، بنجر ، وذرة سكرية) خلال ثلاثة مواسم زراعية متتابعة (2000/99، 2000 ، 2001/2000). بصورة عامة اتضح أن انخفاض المسافة بين خطوط الأنفاق من 3 الي 9 متر أدى الي زيادة الكثافة الظاهرية مع تشجيع غسيل الأملاح من قطاع التربة مما أدى الي زيادة إنتاجية البرسيم والذرة السكرية بصورة واضحة . ولقد تفوقت أنفاق الرمل علي الأنفاق بدون مواد مالئة في تحسين تهوية التربة وخفض ملوحتها وزيادة إنتاج المحاصيل المختلفة. الأنفاق الشبكية المتعامدة كانت بصورة طفيفة افضل من الأنفاق المتوازية علي إنتاجية البرسيم في حين تفوقت الأنفاق المتوازية مع الأرز.

كما اتضح إضافة الجبس كمادة مالئة في الأنفاق أو أضافتها في الطبقة تحت السطحية باستخدام المحراث القلاب كانت افضل من الإضافي السطحية للجبس في تحسين خواص التربة وكذلك زيادة محصول البنجر. اتضح أن معدل 8 طن جبس فدان كان افضل قليلاً من 4 طن فدان وكلا المعدلين كان افضل كثيرا من عدم الإضافة وذلك على خواص التربة ومحصول البنجر.

وقد أتوضح التحليل للاقتصادي أن عمل الأنفاق علي أبعاد 3 متر قد تفوق علي الأبعاد الأخرى وحقق زيادة صافية في دخل المزارع تحت دورة زراعية من البرسيم و السورجم. وان التصميم المتوازي للأنفاق مملوءة بالرمل قد تفوق علي باقي التصميمات والمواد المالئة في دورة تشمل أرز و برسيم . وأيضا اتضح أنه تحت مستويات الملوحة المختلفة فان الأنفاق المملوءة بالرمل حققت صافي دخل للفلاح اكبر من الطرق الأخرى في حالة زراعة محصول القمح أو الشعير. أخيرا فان طريقة إضافة الجبس في أنفاق تعتبر هي الطريقة الوحيدة المفيدة للفلاح والتي تحقق صافي عائد مناسب في حالة زراعة بنجر السكر.

Technical session 6:

Soil Biology and Biofertilizers

- *A.S. El-Hassanin[1], S.A. Shimi[2] and Heba M. Abd-Aziz[2].*

  " Effect of organic fertilizer and acid phase fermentation products of agricultural residues combination with Zn and Mn on growth of corn plant"

  (1. Dept. of Natural resources, Inst. Of African Res. & Studies, Cairo Univ., 2. Soil Water and Environment Res. Inst., Agric. Res. Center).

- *A.S. El-Hassanin[1], S.A. Shimi[2] and Heba M. Abd-Aziz[2].*

  " Acidogenic fermentation of agricultural residues enrichment with digested effluent from biogas digester".

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- *O.A.El-Hadi, S.A. Abou Sedera, and A.A. El-Kader.*

  " Hydrogel for improving the conditioning effect of manures: II. Influence on some chemical and biological properties of sandy soil".

  (National Research Center, Dokki, Giza)

Effect of Organic Fertilizer and Acid Phase Fermentation Products of Agricultural Residues Combination With Zn and Mn on Growth of Corn Plant

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ABSTRACT

Greenhouse experiment was carried out to evaluate effect of chelating foliar spray generated during the acid phase fermentation of tomato shoots or rice straw enriched with Zn and Mn elements on growth and dry matter of corn plants cultivated in virgin sandy soil fertilized with biogas manure (BM) or farmyard manure (FYM). The data revealed that the highest dry matter of corn plants was in extracts case in sandy soil fertilized with BM which treated with extracts of tomato shoots or rice straw as foliar spray. As for interaction treatments, the highest dry matter weights were obtained from Zn x tomato shoots extract (13.414 g/pot) and BM x tomato shoots extract (12.810 g/pot). The highest NPK were recorded in case of BM combined with foliar spray of tomato shoots extract enriched with Zn followed by rice straw extract enriched also with Zn. The FYM treatment was the inferior at the same treatments. Most treatments of extracted solutions of fermented tomato shoots or rice straw either Zn or Mn significantly enhanced the uptake of these elements by corn plants. The highest values of Mn uptake were obtained in case of BM more than FYM when spraying corn plants were sprayed with fermented extracts.

Key words: Acidsgenic fermentation, organic fertilizer, chelating compounds, uptake plants

The term "chelate" refers to the formation of a ring configuration when a metal ion combines with two or more electrons donners and protecting it from being rendered unavailable and useful for growing plants. Chelating agents occur naturally, but can, also be manufactured as so called synthetic chelating agents. The latter forms are used in fertilizers. The synthetic chelating agents are based on acids such as, ethylen diamine tetra acetic acid (EDTA), dielthylene triamine penta-acetic acid (DTPA), ethylene diamine di- o- hydroxyl phenol acetic and (EDDHA). Norvel and Lindsay (1969) found that EDTA and DTPA maintained a large fraction of the applied Fe, Zn and Cu in solution over at least a portion of the pH range. Hashem (1980) observed that the addition of organic materials with wide C/N ratio led to the assimilation of inorganic nitrogen by soil microorganisms, while the addition of organic matter narrows C/N ratio which caused marked increase in inorganic nitrogen as a result of organic matter decomposition by soil microflora. Maramba et al. (1978) stated that biogas manure could replace nitrogen, phosphorus, potassium and trace

elements fertilizers. The effluent of biogas manure supplied N, P, K as well as considerable levels of the micro-elements (Fe, Cu, Mn and Zn) in a suitable form for plants (Mahmoud et al., 1982; Abdel-Aziz et al. 1982; Alaa EL-Din et al , 1983 and 1984 a, b., Mahmoud et al., 1984 a, b.).

It has been shown by many investigators that soil organic matter is one of the main factors affecting micro-elements availability. The rate at which micronutrients are released depends upon conditions affecting microbial activity. Sorensen et al. (1971) reported a positive correlation between extractable zinc and organic matter content .

The effect of organic matter on manganese availability is not, so far quite clear, the conversion of manganese oxides to the reduced manganous ions may be due to either direct reaction with the organic matter or to certain biological processes (Hinsley et al., 1979). Furthermore, type of the organic matter is of great importance. Heavy application of sewage sludge or animal manures increased soil organic carbon levels and potentially caused reducing condition of top soil. This may cause an increase in the levels of available Fe and Mn even several years later (Robertson et al., 1982). Such mobilization may have an important implication in soil fertility and environmental quality especially with regard to other trace elements that tend to associate with Fe and Mn minerals, and appear to become more soluble under reducing conditions (Sims and Patrick, 1978).

The objectives of this study are to evaluate the manure produced from anaerobic fermenting cattle dung, rice straw and tomato shoots and efficiency use of chelating biofertilizer production from the abovementioned residues compared with a farm-yard manure for biological and chemical properties of a sandy soil and growth of corn plant.

MATERIALS AND METHODS

I. Material:

Samples of FYM and biogas manure were air dried and subjected to physical and chemical analyses. The physico- chemical properties of the organic manures is shown in Table (1).

Table (1): Physico-Chemical characteristics of a biogas manure and Farmyard manure.

Organic* manure	Density kg/m^3	Moisture %	O.M %	O.C %	T.N %	T.P %	T.K %	C/N ratio
Farm yard manure (FYM)	875	11.10	10.12	5.87	0.35	0.70	0.57	16.77
Biogas manure (BM)	285	9.28	58.80	38.00	1.45	0.92	0.58	27.20

* Source: Training center for recycling of agricultural residues at Moshtohor, ARC.

Soil sample representing a virgin sandy soil was collected from the surface layer (0-20 cm depth) of Kalyobia Governorate. Mechanical and chemical analyses of the soil are shown in Table (2).

Table (2): Mechanical and chemical analyses of the soil under study.

Determination		Mean value	Determination		Mean value
I- Chemical analysis:			II- Mechanical analysis:		
Organic matter	%	0.10	Coarse sand	%	34.5
Calcium carbonate	%	2.23	Fine sand	%	44.9
Total soluble salts	%	0.03	Silt	%	11.2
pH (1:2.5)		8.50	Clay	%	9.0
Total soluble nitrogen	ppm	50.00			
Available potassium	ppm	400.0			
Available phosphorous	ppm	0.00			
Available zinc	ppm	0.40			
Available manganese	ppm	0.40			

Corn grains (Giza S.C 10 var.) were supplied by the Crops Research Institute, Agricultural Research Center, Giza

2- Methods:

Chemical analysis were determined by methods given by APHA, 1992.

3. Experiments:

Green house experiments were carried out to evaluate the effect of the chelating foliar spray generated during the acid phase fermentation of tomato shoots or rice straw on the growth of corn plants cultivated in sandy soil supplement with different organic manures FYM or BM). Each of B.M or FYM was mixed thoroughly with the soil at the rate equivalent to 0 2 % O.M (equivalent to 2 ton O.M /feddan). Each pot received 8 kg of the soil mixed with the organic manure. Four grains of corn were planted in each pot. All pots were subjected to a basal uniform applications of calcium superphoshate and potassium sulphate at the rates

of 100 kg and 50 kg/ feddan before sowing, respectively. Nitrogen at the rate of 120 kg per feddan as ammonium sulphate was splitted in three equal doses and applied after 15 days from sowing (at thinning to two plants/pot) and the other doses were applied after 7 and 15 days after thinning. Tap water was used to keep the moisture content at 60 % water holding capacity.

The elutriate containing the highest yield of volatile fatty acids for both tomato shoots and rice straw were used as foliar application. The foliar spraying treatments were used after 21 and 30 day from sowing. The following treatments were used for the soil received FYM or B.M: water, EDTA-Zn, EDTA-Mn, Extract of tomato shoots, Extract of tomato shoots + Zn, Extract of tomato shoots + Mn, Extract of rice straw , Extract of rice straw + Zn and Extract of rice straw + Mn.

The experimental design was complete randomized design with six replications. Plant samples were collected after 60 days from planting for the growth record i.e., dry weight (g/pot) and also estimation of N, P, K, Zn and Mn content in the maize plant. Data were statistically analyzed according to the methods described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Dry matter and yield of corn plants:

The effect of farmyard manure (FYM) and biogas manure (BM) with extracts of the most fermentation treatments of tomato shoots and rice straw (with 100 g effluent + 100 g cow- dung) either with Zn and Mn or without any application of micro- elements on the dry matter yield of corn (60 days old) showed that the foliar treatments enhanced significantly the dry matter content of plants as compared to the control treatment (Table 3). The highest figures of the dry matter content (14.83 and 12.75 g/pot) were observed when the plants were treated with the extracts of tomato shoots and rice straw with zinc as foliar spray, respectively, for the manural treatment of biogas. Some improvement was achieved when manganese was applied for the previous treatment (12.435 and 11.617 g/pot, respectively). The difference was, however, not significant. Earth compost (FYM) with or without foliar treatments showed much lower dry weights. The obtained values were 8.82 and 8.325 g/pot for the extracted foliar solutions of tomato shoots and rice straw, respectively, compared with 7.997 g/pot for the control which did not contain zinc or manganese. Moreover, the biogas manure treatments either with or without foliar solutions of tomato shoots and rice straw (-Zn and -Mn application)

exceeded the abovementioned FYM treatments (11.163 and 10.685 g/pot, respectively, compared to 9 g/pot for the control).

The superiority of biogas manure in dry weight production of corn as compared with ordinary earth compost (FYM), is expected because of its rich plant received the fermented extracts of tomato shoots and/or rice straw either in combination with Zn and Mn, compared with the control (water spraying). There were highly significant differences between the two treatments of organic manures. Highly significant results of N, P and K uptake occurred for plants received the biogas manure. These findings are in agreement with the results obtained by Mohamoud et al. (1992, and 1984a and 1982) and Hornick et al. (1979) who found that effluent of biogas manure supplies N, P, K as well as considerable levels of the micro-elements for plants as compared to earth compost. Moreover, these results can be interpreted that chelating characters of biogas manure plays an important role in mobilization as well as availability of micro-nutrients in the soil (Stevenson and Ardakani, 1972 and Sathianthan, 1975).Statistical analysis showed no significant differences between zinc and manganese treatments, however, the plants received Zn showed relatively higher N, P and K contents. Mn was inferior when it was used as foliar spray of the extractants either for the tomato shoots or rice straw fermentation. These results were in agreement with those obtained by Mahmoud et al. (1984a), Abdel-Aziz et al. (1982) and Stevens and Ardakani (1972).

With regard to element (E) X extracts (Es) as interaction treatments, the highest mean values of dry weight were 13.44 and 12.810 g/pot, respectively for Zn x tomato shoots extract and BM x tomato shoots extract treatments followed by 11.542 and 11.683 g/pot, in the same respective order. These increases in dry weights are due to that the growth of corn plants was promoted by tomato shoots extract which contains most efficient zinc as chelating compounds as well as other growth promoters as compared with rice straw extract treatments. Moreover, the dry weight as the result of applying biogas manure with zinc (Es) was more effective due to either the insufficiency of amount provided to the plants with suitable concentration of element or to the probable useful effect of applying zinc as foliar spray treatment under this condition.

2. Nitrogen, phosphorus and potassium contents of corn plants:

It is evident from Tables (4, 5 and 6) that the contents of nitrogen, phosphorus and potassium of corn plants (mg/pot) grown on sandy soil were higher when the plants were treated with Zn values. The corrections were less effective in the case of manganese. So, zinc is an essential

micronutrient that is involved in the same enzymatic functions as Mn. Only carbonic anhydrase has been found to be specifically activated by Zn .

Arroug (1985) stated that application of biogas manure at 1% of the soil weight to corn significantly increased the uptake of N, P, K and subsequently increased the yield of dry matter. So, it could be concluded that biogas manure may efficiency replace nitrogen, phosphorus, potassium and trace elements fertilizers.

Table (3): Effect of organic manure and the acid phase fermentation of tomato and rice straw extract enriched with Zn & Mn on dry weight of corn (g/pot) .

Organic manure (O.M)	Micro-nutrient	Foliar			Mean
		EDTA	Extract: Tomato shoot	Extract: Rice straw	
		Dry weight, g/pot			
Earth compost (Farm yard manure). F.Y.M	0	7.997	8.882	8.325	8.401
	Zn	9.83	11.997	10.330	10.720**
	Mn	8.666	10.250	9.080	9.332
	Mean	8.831	10.376	9.246	9.484
Biogas manure (B.M)	0	9	11.165	10.685	10.283**
	Zn	12	14.830	12.750	13.415**
	Mn	11	12.435	11.617	11.878**
	Mean	11.083	12.810	11.682	11.858**
Mean		9.957	11.593**	10.465	

L.S.D of significant.

		L.S.D 0.01	L.S.D 0.05
Extract solution (ES)	=	1.44	1.096
Organic manure (O.M)	=	1.22	0.925
Element (E) X (O.M)	=	1.77	1.437
(ES) X (O.M) X (E)	=	3.28	

Micronutrient	Foliar			Mean
	EDTA	Extract: Tomato shoot	Extract: Rice straw	
	Dry weight, g/pot			
0	8.499	10.024	9.504	9.341
Zn	11.248**	13.414**	11.542**	12.068
Mn	10.125	11.343**	10.349*	10.605
Mean	9.957	11.593	10.465	
Organic manure				
FYM	8.831	10.376	9.246	9.484
BM	11.083	12.810	11.683	11.857

L.S.D of significant.

		L.S.D 0.01	L.S.D 0.05
Element (E)	=	1.44	1.096
(E) X (ES)	=	2.144	1.632
(O.M) X (ES)	=	1.77	1.347

Table (4): Effect of organic manure and the acid phase fermentation of tomato and rice straw extract enriched with Zn & Mn on nitrogen content of corn plant (mg/pot).

Organic manure (O.M)	Micro-nutrient	Foliar			Mean
		EDTA	Extract		
			Tomato shoot	Rice straw	
		N content, mg/pot			
Earth Compost (Farm yard manure), F.Y.M	0	387.85	421.12	410.21	406.40
	Zn	436.71	496.75	473.36	468.94**
	Mn	418.82	476.19	463.29	453.43**
	Mean	414.46	465.36	448.95	442.92
Biogas manure (B.M)	0	416.33	447.29	429.53	431.05**
	Zn	473.18	501.31	491.07	488.52**
	Mn	451.22	486.30	483.59	473.70**
	Mean	446.91	478.30	468.06	464.42**
Mean		430.69	471.83**	458.51**	

L.S.D of significant:

		L.S.D 0.01	L.S.D 0.05
Extract solution (ES)	=	11.29	8.590
Organic manure (O.M)	=	9.57	7.282
Element (E) X (O.M)	=	13.88	10.561
(ES) X (O.M) X (E)	=	25.74	19.585

Micronutrient	Foliar			Mean
	EDTA	Extract		
		Tomato shoot	Rice straw	
	N content, mg/pot			
0	402.09	434.21**	419.87**	418.72
Zn	454.95**	499.03**	482.22**	478.73
Mn	435.02**	482.25**	473.44**	463.57
Mean	430.69	471.83	458.51	
Organic manure				
FYM	414.46	465.36	448.95	442.92
BM	446.91	478.30	468.06	464.42

L.S.D of significant:

		L.S.D 0.01	L.S.D 0.05
Element (E)	=	11.29	N.S
(E) X (ES)	=	16.56	12.60
(O.M) X (ES)	=	13.88	N.S

Table (5): Effect of organic manure and the acid phase fermentation of tomato and rice straw extract enriched with Zn & Mn on phosphorus content of corn plant (µg/pot).

Organic manure (O.M)	Micro-nutrient	Foliar			Mean
		EDTA	Extract		
			Tomato shoot	Rice straw	
		P content µg/pot			
Earth Compost (Farm yard manure) F.Y.M	0	15.19	20.43	18.32	17.98
	Zn	20.61	31.19	24.80	25.54**
	Mn	19.07	26.65	20.88	22.20**
	Mean	18.30	26.90	21.33	21.91
Biogas manure (B.M)	0	29.02	32.38	29.91	30.44**
	Zn	36.73	45.97	38.25	40.32**
	Mn	31.27	36.06	34.85	34.06**
	Mean	32.34	38.14	34.34	34.94**
Mean		25.32	32.11**	27.84**	

L.S.D of significant:

		L.S.D 0.01	L.S.D 0.05
Extract solution (ES)	=	2.96	2.25
Organic manure (O.M)	=	2.51	1.91
Element (E) X (O.M)	=	3.64	2.77
(ES) X (O.M) X (E)	=	6.76	5.14

Micronutrient	Foliar			Mean
	EDTA	Extract		
		Tomato shoot	Rice straw	
	P content, mg/pot			
0	22.11	26.41	24.12	24.21
Zn	28.69	38.58	31.53	32.93**
Mn	25.17	31.355	27.87	28.13*
Mean	25.32	32.11	27.84	
Organic manure				
FYM	18.30	26.09	21.33	21.91
BM	32.34	38.14	34.34	34.94

L.S.D of significant.

		L.S.D 0.01	L.S.D 0.05
Element (E)	=	2.96	N.S
(E) X (ES)	=	4.34	3.11
(O.M) X (ES)	=	3.64	N.S

Table (6): Effect of organic manure and the acid phase fermentation of tomato and rice straw extract enriched with Zn & Mn on potassium content of corn plant (mg/pot).

Organic manure (O.M)	Micro-nutrient	Foliar			Mean
		EDTA	Extract		
			Tomato shoot	Rice straw	
		K content, mg/pot			
Earth Compost (Farm yard manure), F.Y.M	0	287.89	328.63	304.70	307.07
	Zn	346.69	454.86	386.45	396.00**
	Mn	315.44	375.15	330.51	340.37**
	Mean	316.67	386.21	340.55	347.81
Biogas manure (B.M)	0	343.80	435.44	413.36	397.20**
	Zn	495.20	587.27	497.25	526.57**
	Mn	440.04	491.18	446.09	459.37**
	Mean	426.61	504.63	451.90	461.05**
Mean		371.65	445.42**	396.23**	

L.S.D of significant.

		L.S.D 0.01	L.S.D 0.05
Extract solution (ES)	=	19.80	15.07
Organic manure (O.M)	=	16.75	12.74
Element (E) X (O.M)	=	26.81	20.40
(ES) X (O.M) X (E)	=	49.58	37.72

Micronutrient	Foliar			Mean
	EDTA	Extract		
		Tomato shoot	Rice straw	
	K content, mg/pot			
0	315.85	382.04**	358.53**	352.14
Zn	420.95**	521.07**	441.85**	461.29
Mn	378.14**	433.17**	388.30**	399.87
Mean	371.65	445.42	396.23	
Organic manure				
FYM	316.67	386.21	340.55	347.81
BM	426.61	504.62	451.90	461.05

L.S.D of significant:

		L.S.D 0.01	L.S.D 0.05
Element (E)	=	19.80	N.S
(E) X (ES)	=	28.94	22.02
(O.M) X (ES)	=	26.31	N.S

3- Zinc and Manganese uptake by corn plants:

Most treatments of extracted solutions of the fermented tomato shoots and rice straw either with zinc or manganese enhanced significantly the uptake of Zn and Mn by corn plants as compared to the control (unfoliated treatment). It could be noticed that biogas manure pots receiving zinc as foliar spray (Tables 7 and 8) of tomato shoots and rice straw extracts recorded the highest Zn uptake (361.3 and 341.8 µg/pot) followed by 345.2 and 319.6 µg/pot for plants received the FYM, respectively.

With regard to the effect of manurial treatments (Table 8) on Mn uptake, significant differences at the 1% level were obtained between the most interaction treatments of Mn x OF x Es.

However, no significant differences were found as a result of using either zinc as compared to Mn treatment or between the two extracted solutions of the fermented tomato shoots and rice straw. The highest values of Mn uptake were obtained in case of using the biogas manure (755.29 and 802.51 µg/pot) followed by 718.82 and 687.46 µg/pot when the plants received FYM with the extracted solutions of tomato shoots and rice straw as foliar spray, respectively. However, significant increases in Mn uptake were obtained when applying biogas manure (651.81 and 631.72 µg/pot compared to 596.97 µg/pot) and FYM (608.90 and 601.40 µg/pot compared to 567.79 µg/pot), when spraying corn plants only with the fermented extracts of tomato shoots, rice straw and water (control), respectively.

Regarding the Zn and Mn content of corn plant, statistical analysis showed that interactions of E x Es and Zn x Es showed higher Zn uptake than Mn uptake. However, E x Es and Mn x Es recorded higher values of Mn uptake than Zn uptake. This might be due to that corn plants responded better to Mn than to Zn. It could be also concluded that the application of biogas manure could have severed effects on the virgin soils; it may increase the organic matter content, the available manganese and zinc in the soil, but the ordinary FYM is not sufficient to release these minerals for corn in such soil. Application of biogas manure to plant is expected, therefore, to make supplemental fertilization with nutrient elements (foliar spray) is unnecessary. Arroug (1985), Mahmoud et al. (1992, 1984 a,b and 1982) Abdel Aziz et al. (1982); Hornick et al. (1979) and Sathianathen (1975) found that biogas manure supplies most of the economical crops with NPK nutrients as well as considerable levels of the micro-elements, i.e. Zn, Fe, Mn and Cu in a suitable form.

Table (7): Effect of organic manure and theacid phase fermentation of tomato and rice straw extract enriched wih Zn & Mn on zinc content of corn plant (µg/pot).

Organic manure (O.M)	Micro-nutrient	Foliar			Mean
		EDTA	Extract		
			Tmato sloot	Rice straw	
		Zn content, µg/pot			
Earth Compost (Farm yard manure), F.Y.M	0	244.50	271.30	259.70	258.50
	Zn	298.60	345.20	319.60	321.13
	Mn	261.40	307.80	281.40	283.53**
	Mean	268.17	308.10	286.90	287.72
Biogas manure (B.M)	0	268.30	287.20	273.40	276.30**
	Zn	321.20	361.30	341.80	341.43**
	Mn	282.20	326.90	310.60	307.00**
	Mean	291.00	325.13	308.60	308.24**
Mean		279.58	316.62**	297.75**	

L.S.D of significant:

		L.S.D 0.01	L.S.D 0.05
Extract solution (ES)	=	12.05	9.17
Organic manure (O.M)	=	10.21	7.77
Element (E) X (O.M)	=	14.60	11.26
(ES) X (O.M) X (E)	=	27.46	20.90

Micronutrient	Foliar			Mean
	EDTA	Exact		
		Tomato shoot	Rice straw	
	Zn contet, µg/pot			
0	256.40	279.25**	266.55	267.40
Zn	309.90**	353.25**	330.70**	331.28
Mn	272.40**	317.35**	296.00**	295.25
Mean	279.58	316.62	297.75	
Organic manure				
FYM	268.17	308.10	286.90	287.72
BM	291.00	325.13	308.60	308.24

L.S.D of significant:

		L.S.D 0.01	L.S.D 0.05
Element (E)	=	12.05	N.S
(E) X (ES)	=	17.66	13.44
(O.M) X (ES)	=	14.80	N.S

Table (8): Effect of organic manure and the acid phase fermentation of tomato and rice straw extract enriched with Zn & Mn on manganese content of corn plant (µg/pot).

Organic manure (O.M)	Micro-nutrient	Foliar			Mean
		EDTA	Extract		
			Tomato shoot	Rice straw	
		Mn content µg/pot			
Earth Compost (Farm yard manure), F.Y.M	0	567.79	608.90	601.40	592.70
	Zn	632.81	664.91	662.94	663.55**
	Mn	639.76	718.82	687.46	682.01**
	Mean	613.45	674.21	650.60	646.09*
Biogas manure (B.M)	0	596.97	651.81	631.72	626.83**
	Zn	675.41	718.32	781.35	725.03*
	Mn	697.34	755.29	802.51	751.711
	Mean	656.57	708.47	738.53	701.19
Mean		635.01	691.35**	694.58**	

L.S.D of significant

		L.S.D 0.01	L.S.D 0.05
Extract solution (ES)	=	31.97	24.33
Organic manure (O.M)	=	27.09	20.62
Element (E) X (O.M)	=	39.28	22.28
(ES) X (O.M) X (E)	=	72.87	55.45

Micronutrient	Foliar			Mean
	EDTA	Extract		
		Tomato shoot	Rice straw	
	Mn content, µg/pot			
0	582.38	630.36	616.60	609.78
Zn	654.11**	706.62**	722.15**	694.29
Mn	668.55**	737.06**	744.99**	716.87
Mean	635.01	691.35	694.58	
Organic manure				
FYM	613.45	674.21	650.60	646.09
BM	656.57	708.47	738.53	701.19

L.S.D of significant

		L.S.D 0.01	L.S.D 0.05
Element (E)	=	31.97	N.S
(E) X (ES)	=	46.87	35.67
(O.M) X (ES)	=	39.28	N.S

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تأثير التسميد العضوي ونواتج التخمر الحامضي للمخلفات الزراعية المثراه بالزنك والمنجنيز على نمو نبات الذرة

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في هذه الدراسة استخدم سماد البيوجاز المنتج من تخمير روث الماشية وقش الأرز وعروش الطماطم وإنتاج مستخلص تم إثراءه بالزنك والمنجنيز وذلك لإنتاج سماد حيوي مخلبي لدراسة تأثيره على النمو والمادة العضوية على نبات الذرة المنزرع في أرض رملية بكر ثم تسميدها بالسماد البلدي أو سماد البيوجاز كل على حده أو بدون تسميد.

وقد وجد أن أعلى تفاعل في المعاملات الأعلى وزناً كان للسماد الجاف 12.810-13.414 جرام/الأصص على التوالي: الزنك مع سماد البيوجاز ومستخلص عروش الطماطم.

وبالنسبة لمحتوى النبات من لنيتروجين والفوسفور والبوتاسيوم كان هناك اختلافاً واضحاً من المعاملتين مع الأسمدة العضوية فوجد أن المعاملة بسماد البيوجاز أعطت إلى حد كبير نتائج هامة بالنسبة لمحتوى النبات من النيتروجين والفوسفور والبوتاسيوم وكذلك كانت نتائج المعاملات المستخدم فيها عروش الطماطم والزنك أعلى من المستخدم فيها مستخلص قش الأرز والزنك.

أي أن معدل الاستفادة للنبات من العناصر كان في حالة التسميد بالبيوجاز مع المستخلص المضاف له الزنك كان أفضل منه في حالة استخدام السماد البلدي مع المستخلص و المنجنيز.

Acidogenic Fermentation of Agricultural Residues Enrichment With Digested Effluent From Biogas Digester

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ABSTRACT

Three concentrations, 2, 4 and 6% of leachates produced from mixture of rice straw or tomato shoots and digested effluent produced from operated biogas digester were evaluated in the generation of VFA when mixed with fresh cow dung and/or (NH4)2 SO4 under anaerobic fermentation system. The highest amount of TVFA was produced at 4% leachate for the two plant residues. A positive relation was found between TVFA production and organic substances, while (NH4)2 SO4 treatment showed lower yield of TVFA. The accumulation of ammonia in a gradual increase was associated with higher level of pH. The leachate concentration, 4%, of either tomato shoots or rice straw with 100 ml effluent and 100 g cow dung throughout the fermentation period was amongst. The most suitable fermented substates for highly generation of organic acids may be used as chelating compounds for the production of high value products like trace elements for nutrient solutions.

Key words: anaerobic digestion, acidogenic fermentation, Digested slurry, volatile fatty acids, chelating compounds

Biochemical compounds having chelating characteristics such as simple aliphatic acids and amino acids, are continuously produced in soil through the activities of microorganisms. These constituents normally have only a transitory existence; accordingly, the amounts present in the soil solution at any time represent a balance between synthesis and destruction by microorganisms. Soils amended with manures and other organic wastes may also be relatively rich in metal binding biochemicals. Since chelating agents have the ability to transform solid phase forms of micronutrient cations into soluble metal complexes, their production during decay of plant and animal residues may increase the availability of insoluble micronutrients to plants. Natural chelating substances have been found in leachates from the more and mull humus horizons of forest soils (Hodgson, et al. 1966). Researches by Hodgson, et al. (1966) and Geering, et al. (1969) show that from 98 to 99% of Cu, 84 to 99% of Mn, and up to 75 % of Zn in displaced soil solutions occurred in organic complexes. The acidogenic process has been widely studied by different authors as the first step of the anaerobic digestion (Ghosh and Klass,1978; Hanki et al., 1987; Verrier et al., 1987; Zhang and Noike, 1991; Ghosh, 1990; Weiland, 1992). One of the most important studies at pilot - plant scale is the one carried out by Albin et al. (1989). Their experimentation is particularly interesting because it was characterized by a high TS content of the sludge

(agricultural wastes), around 14-22 % TS. The retention time employed in the acidorgenic reactor was 10 days, and between 25 and 35% of the initial COD in the feed was acidifed mainly to acetic and butyric acids.

Adderio et al. (1992) studied acidorganic fermentation, at laboratory-scale level, using different reactor designs and mechanically selected of municipal solid wasted (MSW) as the substrats. Results were obtained with a batch reactor working with a retention time of 12 days, and an initial TS content of 15 %. The total volatil fatty acids (TVFA) production reached 15 g/L. The production of VFA by anaerobially fermenting an organic substrate has already been studied by different authors in mesophilic conditions (Antono Poulos and Wene 1988; Albin et al., 1989; D'Addaio et al., 1992). The study carried out by Verrier Workers on digestng agroindustrial refuses is an approach for comparing the acidogenic fermentation yields obtained were higher at 60 °C than at 35 °C and VFA production favoured the production of acetic and butyric acids rather than propoinic and vleric acids. El-Housseini et al. (1998) reported that concentrations of VFS and Ethanol increased during anaerobic fermentation. Beauchamp (1989) studied the relationship between volatile fatty acids, total ammonia and pH in manure slurries. They stated that the slurry pH was largely determined by volatile fatty acids and total ammonia concentration increased as (VFAs) /(NH_4^+ + NH_3) ratio decreased.

The aim of this study is to evaluate the effect of VFA generated during anaerobic fermentation of rice straw or tomato shoots on corn plant. The produced natural extracts enriched with Zn or Mn were evaluated as chelating complex on corn plant cultivated in virgin sandy soil fertilized with farm yard manure or biogas manure.

Mixture of plant residues and animal wastes after fermentation period produced the highest amounts of organic acid that may be used as chelating compound for the production of hugh value products like trace elements for nutrient solutions (foliar spray)

MATERIALS AND METHODS

1) Materials:

Tomato shoots and rice straw were air dried and pulverized before being used. Fresh collecting dung were used. The chemical analysis of raw materials under consideration is presented in Table (1).

Table (1): Chemical composition of raw materials.

Crop residue	T.S%	V.S%	O.C%	TN%	TP%	C/N ratio	pH
Tomato shoots	45.00	74.62	43.28	1.960	0.878	22.1 : 1	5.5
Rice straw	93.08	78.62	45.62	0.762	0.292	59.9 : 1	7.5
Cattle dung	14.06	83.49	48.13	1.73	0.65	24.7:1	8.98

2) Methods:

Chemical analysis were determined by methods given by APHA, 1992.

3) Experimental:

A pilot experiment was carried out in glass jars of 5 liter capacity with working volume 3 litre sealed with heavy stopcock rubber and kept at room temperature, where the following treatments were used;

Treatment (1) Tomato shoots or rice straw at 2, 4 and 6% concentrations in 3 litre water (Control), (2) treatment 1 + 100 ml biogas effluent, (3) Treatment 2 + 0.4 g $(NH_4)SO_4$. (AS), (4) Treatment 2 + 100g cow dung (C.D) and (5) Treatment 4 + 0.4 g of (A.S).

The treatments were tested every day during the experimental period TVFA, ammonia concentration and pH were determined daily during the acid phase fermentation period (10 days).

RESULTS AND DISCUSSION

1- Production of volatile fatty acids:

It is quite evident from the results obtained that (VFAs) production was significant to fermented plant. Regardless of the organic material and fermentation periods, the application of 4 and 6% rice straw resulted in increases of 12.4 and 11.2%, (VFAs) respectively (Table 2) compared with the application of 2% rice straw. The same trend was also obtained with tomato shoot, the respective increases were 14.2 and 12.1%. The highest increase in (VFAs) was obtained with the application of 4% fermented plant. The data presented in Table (2) showed that irrespective of the fermented plant and fermentation periods, the differences in the production of volatile fatty acids resulting from the different organic amendments were very great. The application of 100 ml effluent, (100 ml as effluent + 0.4 gm $(NH_4)_2 SO_4$), (100 ml Effluent + 100 gm cattle dung) and 100 ml Effluent + 100 gm cattle dung + (0.4 gm $(NH_4)_2 SO_4$) resulted

in average increases in the volatile fatty acids amounted to 79.6, 3.5, 34.0 and 10.7 %m, respectively, compared with control treatments in rice straw. The same trend was also obtained with tomato shoots, the respective increases were 48.5, 55.4, 113.9 and 12.8%. Adderio et al. (1992) reported that VFAs reached 15g/L when fermented MSW for 12 days at TS 15%.

The effect of the interaction between fermented plant and organic materials on the VFA production was found to be insignificant with rice straw. However, the highest VFA produced obtained when fermented plant was applied at the rate of 4% with 100 ml Effluent + 100 gm cow dung + 0.4 gm (NH4)2 SO4. Unlike the rice straw, the statistical analysis showed that the effect of the interaction between fermented plant and organic substance was significant in the tomato shoots, 4% of fermented plant 100 ml effluent 100 gm cow dung to 0.4 gm (NH4)SO4 was the most optimum level to produce the highest volatile fatty acid. The effect of the interaction between the various treatments fermented plant and fermentation period on increasing the volatile fatty acid of rice straw was found to be insignificant. However, in the tomato shoots volatile fatty acid formation was enhanced by the application of 100 ml effluent + 100 gm cow dung at 5 days from fermentation period, either with the rice straw or the tomato shoots.

The effect of the interaction between the different factors proved to be insignificant in rice straw. However, this effect was significant in tomato shoots. In the rice straw, the lowest amount of volatile fatty acid was attained when 2% rice straw or tomato shoots was applied without organic substrate. While the highest values of volatile fatty acid was achieved by applying 4% rice straw or tomato shoots with 100 ml effluent+100 gm cow dung after 5 days from fermentation. Albin et al. (1989) observed that the HRT in the acid organic reactor was 10 day when TS content of agriculture residues was around 14-22%.

2. Changes in pH during acidogenic fermentation of crop residues :

Values reveal that highly significant effect was obtained for the fermented plant on pH values, i.e. increasing the rate of fermented plant application resulted in a corresponding decrease in the pH values in both fermented plants. In the rice straw, regardless of organic substrate and fermentation periods, the average decreases were 10.3 and 6.5 % when rice straw was applied at the rate of 4 and 6%, respectively compared with the application of fermented plant at the rate of 2%, Table (3). In tomato shoots, the respective decreases of these rates were 9.4 and 6.5%. The

effect of substrate on pH values was found to be also significant in both source of fermented plants. Regardless of fermented plant rates and fermentation period, the application of 100 ml effluent + 100 gm cow dung gave the lowest pH value among all tested factors in both fermented plants, however, the highest pH value among all tested factors in both fermented plant, however, the highest average pH value was actived by the application of 100 ml effluent + 0.4 mg $(NH_4)_2$ SO_4. The effect of fermentation periods on pH values was found to be highly significant either with rice straw or in tomato shoots. Increasing the fermentation period decreased the pH values up to 5 days from fermentation. On the other hand, increasing of fermentation period more than 5 days increased the amounts of pH values in both fermented plant materials. The effect of the interaction between organic substrate and time of fermentation on pH value was found to be insignificant in both fermented plants.

The lowest pH was attained when the organic substrate was applied as 100 ml Effluent with 0.4 gm $(NH_4)_2$ SO_4 or with 100 gm cow dung, at days from fermentation, whereas the highest values of pH were achieved by water control at 10 days from fermentation. The effect of interaction between fermented plant and time of fermentation on pH values was found to be also insignificant in both fermented plants. In case of the rice straw, the highest values of pH were obtained at 2% of fermented plant application at 4 days from fermentation. On the other hand, the lowest value was recorded for the application of fermented plant at the rate of 4% after 5 days from fermentation with both fermented plants.

The effect of the interaction between fermented plant and organic substrate on pH value was found to be insignificant in both fermented amendments. The highest values were scored when fermented plant was applied at the rate of 2% alone where the lowest value was recorded when the fermented plant was introduced as 6% with 100 ml effluent + 0.4 gm $(NH_4)_2$ SO_4 and 4% with 100 gm effluent by tomato plants and rice straw, respectively. The effect of interaction between organic substrate, fermented plant and fermentation period on pH values was formed to be also insignificant in both fermented plant. The highest value was attained when the fermented plant was applied at the rate of 2% alone after 10 days from fermentation. with both fermented plants. Whereas the lowest values were obtained when the fermented plant was applied at the rate of 6% with 100 ml effluent + 0.4 gm $(NH_4)_2SO_4$ and 4% with 100 ml effluent + 100 gm cow dung in tomato shoots and rice straw, respectively. Takai et al. (1987) noted that the pH was lowered during anaerobes and encouraged organic acids accumulated in large amounts in paddy soils.

Table (2): Production of volatile fatty acids by acidogenic fermentation of rice straw (μg/liter).

The fermented Plant (%)	Organic substrate	Fermentation period in days										
		1	2	3	4	5	6	7	8	9	10	Mean
2	Water (control)	8.66	11.92	15.84	23.62	25.92	17.87	13.36	11.68	9.33	8.92	7.120
	100 g effluent (E)	13.55	19.19	26.24	33.02	38.34	27.27	26.86	19.09	15.53	14.78	23.387
	100 g (E)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	9.56	11.51	16.66	23.11	25.09	16.61	13.26	11.82	10.30	9.90	14.788
	100 g (E) +100g cow dung (C.D)	21.51	27.79	36.16	46.01	49.13	39.02	37.70	27.12	24.41	21.66	33.051
	100 g (E) +100g (C.D) + 0.4g (AS)	10.92	12.29	18.26	25.11	27.35	18.20	14.85	12.10	11.77	11.81	16.266
	Mean	12.84	16.54	22.65	36.17	33.10	23.79	21.206	16.360	14.260	13.414	21.039
4	Water (control)	10.57	15.24	18.25	26.91	29.19	20.78	16.78	14.81	11.95	11.16	17.564
	100 g effluent (E)	18.12	25.89	39.12	46.86	50.13	37.78	35.01	26.64	30.12	27.11	33.678
	100 g (E)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	11.01	16.99	20.26	27.07	30.90	21.30	17.71	15.41	12.56	11.72	18.493
	100 g (E) +100g cow dung (C.D)	27.01	36.30	45.73	57.39	60.25	48.12	43.27	34.41	31.05	27.96	41.119
	100 g (E) +100g (C.D) + 0.4g (AS)	12.14	17.52	21.85	27.61	31.51	21.91	19.14	16.56	13.32	12.16	19.372
	Mean	15.770	22.380	29.050	37.168	40.396	29.978	26.380	21.504	19.800	18.022	26.045
6	Water (control)	9.16	14.81	17.25	25.81	28.91	18.73	15.82	12.82	10.18	9.61	16.310
	100 g effluent (E)	16.00	23.49	37.85	44.46	48.81	35.60	33.55	24.14	14.88	17.88	30.171
	100 g (E)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	10.92	13.11	18.12	26.12	29.12	19.50	16.31	14.68	11.60	10.96	16.984
	100 g (E) +100g cow dung (C.D)	25.51	34.84	43.96	55.15	59.26	47.14	41.65	32.25	29.25	26.01	39.502
	100 g (E) +100g (C.D) + 0.4g (AS)	11.51	15.41	19.68	27.35	20.73	20.66	17.71	14.87	12.12	11.57	17.161
	Mean	14.620	20.330	27.370	35.778	33.376	28.326	25.000	19.750	16.486	15.206	23.624
Mean		14.410	19.750	26.356	36.370	35.640	27.360	24.195	19.205	16.848	15.547	

L.S.D		5 % level	1% level
Fermented plant	:	1.92	2.51
Organic substrate	:	2.47	3.24
Periods	:	3.50	4.58
Organic x Periods		n.s	n.s
Fermented plant x Organic substrate	:	n.s	n.s
Fermented plant x Periods	:	n.s	n.s
Fermented plant x Organic substrate x Periods	:	n.s	n.s

Table (3): Changes in pH values after acidogenic fermentation of tomato shoots.

The fermented Plant (%)	Organic substrate	Fermentation period in days										
		1	2	3	4	5	6	7	8	9	10	mean
2	Water (control)	6.49	6.23	5.99	5.81	5.57	5.71	5.99	6.27	6.37	6.44	6.084
	100 g effluent (E)	6.07	5.82	5.58	5.39	5.18	5.31	5.41	5.67	5.89	6.01	5.633
	100 g (E)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	6.42	6.18	5.92	5.68	5.46	5.59	5.77	6.07	6.26	6.34	5.969
	100 g (E) +100g cow dung (C.D)	5.93	5.59	5.30	5.16	5.00	5.19	5.26	5.52	5.71	5.88	5.454
	100 g (E) +100g (C.D) + 0.4g (AS)	6.28	6.02	5.87	5.61	5.39	5.42	5.54	5.78	6.06	6.22	5.819
	Mean	6.236	5.960	5.730	6.670	5.320	5.440	5.650	5.860	6.058	6.172	5.912
4	Water (control)	6.10	5.92	5.71	5.58	5.41	5.48	5.74	5.94	6.13	6.16	5.817
	100 g effluent (E)	5.90	5.69	5.52	5.25	5.16	5.18	5.32	5.49	5.84	5.98	5.533
	100 g (E)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	5.60	5.41	5.24	5.09	4.95	5.01	5.06	5.31	5.51	5.61	5.279
	100 g (E) +100g cow dung (C.D)	6.04	5.79	5.67	5.50	5.34	5.37	5.51	5.81	6.03	6.08	5.714
	100 g (E) +100g (C.D) + 0.4g (AS)	5.72	5.56	5.39	5.24	5.11	5.09	5.21	5.42	5.65	5.79	5.418
	Mean	5.630	5.470	5.312	5.178	5.040	5.124	5.270	5.490	5.724	5.802	5.404
6	Water (control)	5.86	5.72	5.51	5.39	5.19	5.37	5.63	5.83	6.00	6.04	5.654
	100 g effluent (E)	5.66	5.49	5.33	5.19	5.05	5.08	5.22	5.39	5.74	5.87	5.402
	100 g (E)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	5.38	5.22	5.05	4.91	4.86	4.92	4.98	5.22	5.41	5.51	5.146
	100 g (E) +100g cow dung (C.D)	5.80	5.63	5.46	5.31	5.16	5.26	5.41	5.70	5.92	5.94	5.559
	100 g (E) +100g (C.D) + 0.4g (AS)	5.49	5.33	5.21	5.09	4.96	4.99	5.11	5.33	5.55	5.65	5.271
	Mean	5.870	5.670	5.500	5.390	5.190	5.220	5.360	5.594	5.830	5.90	5.550
Mean		5.912	5.70**	5.51**	5.74**	5.18**	5.26**	5.58**	5.65**	5.87**	5.96**	

L.S.D		5 % level	1% level
Fermented plant	:	0.50	0.07
Organic substrate	:	0.07	0.09
Periods	:	0.10	0.13
Organic x Periods		n.s	n.s
Fermented plant x Organic substrate	:	n.s	n.s
Fermented plant x Periods	:	n.s	n.s
Fermented plant x Organic substrate x Periods	:	n.s	n.s

Table (4): Production of $NH4^+$ by acidogenci fermentation of tomato shoots (mg/liter)

The fermented Plant (%)	substrate	Fermentation period in days										
		1	2	3	4	5	6	7	8	9	10	Mean
2	Water (control)	-	-	-	-	-	6.32	13.10	22.90	28.40	29.80	10.052
	100 g effluent (E)	72.60	66.30	51.20	43.30	39.40	36.60	46.40	56.70	68.90	69.10	55.050
	100 g (F)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	120.10	103.90	83.70	59.80	49.90	43.80	61.40	81.80	94.30	108.20	80.690
	100 g (E) +100g cow dung (C.D)	54.01	501.70	458.30	407.80	344.10	337.40	339.50	355.80	394.10	401.30	408.01
	100 g (E) +100g (C.D) + 0.4g (AS)	335.40	288.10	245.40	225.40	218.60	335.70	360.60	388.20	415.80	436.50	324.97
	Mean	213.64	192.00	167.72	147.26	130.40	151.96	164.20	181.08	300.30		175.75
4	Water (control)	-	-	-	-	-	15.40	20.20	37.20	42.30	50.70	16.58
	100 g effluent (E)	66.60	62.90	48.30	40.10	37.30	32.10	71.20	93.40	100.20	107.70	65.98
	100 g (E)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	115.40	99.80	77.40	52.30	44.10	38.90	91.40	127.30	141.20	159.60	94.74
	100 g (E) +100g cow dung (C.D)	520.60	481.20	433.90	397.60	342.20	321.30	426.20	533.00	551.20	572.90	58.01
	100 g (E) +100g (C.D) + 0.4g (AS)	329.30	269.20	240.20	218.30	215.70	210.50	379.40	396.20	452.30	472.40	318.85
	Mean	206.32	182.62	159.96	141.66	127.36	133.64	197.70	237.42	257.44	272.66	190.73
6	Water (control)	-	-	-	-	-	7.24	16.30	24.20	35.70	43.20	12.66
	100 g effluent (E)	69.30	65.40	50.20	41.30	38.20	34.70	52.30	70.70	96.20	94.30	73.56
	100 g (E)+ 0.4g $(NH)_4$-$2SO_4$ (AS)	118.30	101.40	80.20	57.40	48.10	42.70	71.30	97.40	101.30	111.80	32.99
	100 g (E) +100g cow dung (C.D)	536.20	493.70	451.20	403.60	351.40	331.40	386.10	499.20	536.20	551.30	454.03
	100 g (E) +100g (C.D) + 0.4g (AS)	331.70	272.30	241.10	221.40	220.10	213.20	360.10	381.20	431.70	452.20	312.50
	Mean	211.10	186.56	164.54	144.74	131.56	124.84	177.22	214.54	240.55		184.59
Mean		210.35	187.06	164.07	144.55	129.94	133.48	179.70	211.01	232.65	245.06	

L.S.D		5 % level	1% level
Fermented plant	:	4.31	5.66
Organic substrate	:	5.56	7.30
Periods	:	7.85	10.32
Organic x Periods		17.56	23.08
Fermented plant x Organic substrate	:	9.62	12.64
Fermented plant x Periods	:	13.61	17.88
Fermented plant x Organic substrate x Periods	:	30.42	39.98

3. Effect of acidogenic treatments on ammonia production:

Quantities produced revealed that significant effect was attributed to the organic substrate with both fermented plant residues. For rice straw treatments, regardless of the rates of fermented plant and time of fermentation, the average values were 9.605, 43.71, 72.494, 406.75 and 265.86 mg NH_4 when organic substrate was applied as water control, 100 ml effluent, (100 ml effluent + 0.4 gm $(NH_4)SO_4$), (100 ml effluent + 100 gm cow dung and 100 gm effluent + 100 gm cow dung + 0.4 gm $(NH_4)SO_4$, respectively, (Table, 4). In tomato shoots treatment the respectively values for the applied organic substrate were 12.43, 60.76, 86.138, 440.01 and 318.6 mg/L. The result show that the response of organic substrate applications was higher in tomato shoots than in rice straw. The effect of the fermented plant application rates on the production of NH_4^+ was found to be also significant with both fermented plants. Regardless of organic substrate and time of fermentation, the application of plant residue at the rate of 4% resulted in the highest amounts of ammonia for both fermented plants. Increasing the time of fermentation decreased the amounts of ammonia produced up to 5 days of fermentation. Increasing time of fermentation increased the amounts of ammonia formed. The effect of the different interactions between the various treatments on the ammonia production was found insignificant in both fermented plants. The data reveal that the highest amount of ammonia was formed when fermented plant was applied at the rate of 4% with 100 gm effluent + 100 ml cow dung at 10 days from fermentation in both fermented plants. Beauchamp (1989) studied the relationship between volatile fatty acids, total ammonia and pH in manure slurries. They stated that the slurry pH was largely determined by volatile fatty acids and total ammonia concentration increased as (VFAs) /(NH_4^+ + NH_3) ratio decreased.

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الملخص العربى

إنتاج الأحماض العضوية بتخمير المخلفات الزراعية المضاف إليها سماد البيوجاز السائل.

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استخدم ثلاثة تركيزات 2، 4،6 من البقايا النباتية المستخدمة من قش الأرز وعروش الطماطم مع (سماد البيوجاز قبل التجفيف الهوائي والذي يستخدم كبادىء بكتيري) مع روث ماشية طازج وكبريتات الأمونيا تحت ظرف التخمير اللاهوائي.

سجلت أعلى قيمة لمجموع الأحماض العضوية المتطايرة فى حالة استخدام التركيز 4% من البقايا النباتية وذلك لكل من قش الأرز وعروش الطماطم كل على حده وذلك بعد 5 أيام من التخمير اللاهوائي. سجلت مجموع الأحماض العضوية المتطايرة أقل قيمة لها فى حالة استخدام كبريتات الأمونيا مع الماء (كنترول).

زيادة تراكم الأمونيا تدريجياً وارتبطت الزيادة بمستوى الحموضة العالي عند استخدام نسبة 4% من عروش الطماطم أو قش الأرز مع 100 مللى سماد خارج من المخمر مع 100 جرام روث ماشية خلال فترة التخمير وهذه كانت الأكثر مناسبة لإنتاج أعلى كمية من الأحماض التي يمكن استخدامها كمركبات مختلفة لإنتاج كمية عالية من العناصر المغذية الصغرى في صورة محاليل مغذية.

Hydrogels for Improving the Conditioning Effect of Manures II. Influence on Some Chemical and Biological Properties of Sandy Soil

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ABSTRACT

A green house experiment with four replications was conducted in a complete randomized system using ryegrass as an indicator plant. Examined treatments were : a) Untreated Rafah (Sinai) sandy soil . b) Soil treated with 2% or 4% organic manure (OM). c) Soil treated with 0.2 % of each of the acrylamide hydrogels (G1) nonionic , (G2) anionic, (G3) cationic and (G4) mixture of (G2) and (G3) at the rate of 2:3 (w/w) . d) Soil treated with mixtures of OM and hydrogels mentioned above (G) at the rate of 1% OM +0.1% G, 2% OM + 0.1% G and 2% OM + 0.2% G. Fertigation was applied using 1g/l fertilizer solution 19:19:19. After the 3rd cut of ryegrass i.e. after 150 days of plantation , some chemical and biological properties of the soil were determined.

Soil conditioning slightly decrease soil pH and increase both CEC of the soil and its specific surface area indicating an improvement in activating chemical reaction in the soil. Increments in OM % , organic carbon content , total and organic nitrogen in the soil were realized by soil conditioning. Because the increase in total nitrogen is higher than that in organic carbon, narrow CN ratios of treated soil were obtained indicating the easy mineralization of organic nitrogen compounds and hence the possibility to save and provide available forms of N to growing plants.

Moreover availability of N, P and K in treated soils were considerably increased. Biological activity of the soil measured by total number of micro- organisms (bacteria, fungi and actinomycetes / g soil) and the activity of both dehydrogenase and phosphatase enzymes were improved. Mixing both types of soil conditioners together was more efficient in improving soil properties than applying each of them alone.

Application rate of mixtures components and ionicity of applied hydrogels are considered of the important factors that highly affect soil conditioning . Results clarify the high efficiency of using mixtures of anionic and cationic hydrogels (G4) particularly when combined with organic manure.

Keywords. Sandy soils, Hydrogels manures soil conditioning, Bio -- Chemical soil properties, pH , CEC, surface area C:N, N, P and K availability, Micro -- organisms , dehydrogenase, phosphatase activity

INTRODUCTION

Because of the shortage that occurred in the quantities of farmyard manures and composts as natural amendments for reclaiming sandy soils the problem of finding substitutes has been posed. Considerable attention has been paid in the last few years to use synthesized soil conditioners to avail suitable environment for planting sandy soils under the severe conditions of our deserts. i.e. the limited water resources, the in adequate water retention and low fertility of the soils . Among these conditioners are hydrogels. Hydrogels (super absorbent materials) are hydrophilic organic polymeric products that associate quickly with irrigation water to form gels. When mixed with sandy soils, they increase its capacity to retain water . Water retained in this way is available to plants for some considerable time, as required.

Due to the binding effect of hydrogel molecules with sand particles and their sewllability, an improved and stable structure of the soil is obtained . Beside , beneficial changes in soil porosity, particularly the amount of water retaining pores, were achieved by soil conditioning . Moreover , most of biochemical and nutritional status of these soils (CEC , Surface area, retention and available of nutrients and biological activity in the soil) were also improved . Accordingly, plant growth, nutrients uptake, yield and both water and fertilizer use efficiency by plants were beneficially increased by mixing the plant pits in sandy soils with hydrogels (El-Hady, 1987 and 1988 Azzam and El-Hady 1983 , El-Hady et. al ., 1981, 1983, 1990 and 1991-b) One of the main factors that play a great role on the nutritional status of treated sandy soils with hydrogels - although it did not take great attention from most of soil scientists uptil now - is their iconicity i.e type and quantity of internal or external charges on the hydrogel molecule. Pieh and El-Hady, 1990, El-Hady et al .,1989, 1991-a and 2000-a , El-Hady and Abd El-Hady, 1997.)

It is also expected that applying organic materials mixed with the proper hydrogels in the plant pits of sandy soil may be more effective and economic than using each of them alone. (El-Hady et al., 1995,a and b and 2000 and Abd El-Hameid et.al., 1995, El-Sherbiny et al., 1995, Arafat and El-Hady, 2000).

Studying the effect of incorporating organic manure or / and acrylamide hydrogels having different ionicity in sandy soil on some bio- chemical properties of the soil is the aim of the present work

MATERIALS AND METHODS.

1. Materials:

1.1 Soil:

A virgin sandy soil from the experimental farm of National Research Center (NRC) at Rafah (North Sinai) was chosen . The soil is sandy in texture. More than 85% of particles are > 20 μ. The main analytical data of the soil are presented in Table (1).

Table (1) Analytical properties of Rafah sandy soil

1.Mechanical analysis

Sand		Silt >200 - 20μ %	Clay > 2 μ %	Soil Texture
Coarse > 200 μ %	Fine >200 - 20μ %			
56.7	31.8	8.0	3.5	Sandy

2.Chemical analysis

pH 1:2.5	EC dSm^{-1}	$CaCO_3$ %	CEC C mole kg^{-1}	OM %	Macro – nutrients (ppm)					
					Total			Available		
					N	P	K	N	P	K
8.56	0.5	3.63	3.02	0.12	560	926	1908	39	12	144

3.Hydrophysical analysis

Bulk density kg^{-1}	Total porosity %	Water holding capacity* %	Field capacity* %	Wilting Percent-age*	Hydraulic conductivity m day^{-1}	Mean diameter of soil pores μ
1.603	39.47	19.64	6.12	1.31	9.15	18.7

*On weight basis

1.2. Soil conditioners:

The following natural and synthesized soil conditioners were examined :

a – Farm yard manure:

The used manure is an organic and animal residues including some soil minerals (mineral matter) . Analysis of OM used in the present work are given in Table (2).

b- Super absorbent materials (Acrylamide hydrogels):

The following acrylamide hydrogels (G) were investigated:

I- Non – ionic hydrogel (G1)

Propeneamide polymer chemically crosslinked with a divalent vinylmonomer (polyacrylamide gel).

II- Anionic hydrogel (G2)

Propeneamide - propionic acid - copolymer chemically crosslinked with a divalent vinylmonomer (K salt) , i.e. polyacrylamide K polyacrylate gel.

III-Cationic hydrogel (G3)

Propeneamide polymer with hydrophilic cationic groups (allyl amine) crosslinked with a divalent vinyl monomer (Cl salt), i.e. polyacrylamide allyl amine hydrochloride gel.

Table (2) Some chemical properties and composition of manure (OM) used as a natural conditioner for Rafah sandy soil.

Property		Value
pH (H_2O)		8.20
Salinity : EC dSm-1		1.60
Na^+ (%)		0.12
Moisture: (%)		7.27
Mineral content % (Ash %)		28.70
Organic component : O.M %		64.03
	O.C %	37.14
	O.N %	1.95
	C:N	18.85
Macro Elements :	$NH^+_4 + NO^-_3$ (%)	0.02
	P_2O_5 (%)	0.04
	K_2O (%)	1.26
Secondary elements :	Ca^{2+} (%)	0.49
	Mg^{2+} (%)	0.25
Micro elements:	Fe (ppm)	2.65
	Mn (ppm)	76
	Zn (ppm)	55
	Cu (ppm)	9.0
Heavy metals :	Cd (ppm)	0.3
	Co (ppm)	2.2
	Ni (ppm)	2.5
CEC	C mole kg^{-1}	125

IV- Mixture of anionic and cationic hydrogels at the ratio of 2:3 (G4):

Polyacrylamide K acrylate gel (G2 - anionic) + polyacrylamide allyl amine hydrochloride gel (G3 - cationic). Since the degree of anionicity for the anionic hydrogel was 30% while the degree of cationicity for cationic one was only 20% , the ratio between the former and the later in the mixture was chosen as 2:3.

Description of the main constituents and properties of the used acrylamide hydrogels are presented in Table (3). It is interesting to note that the used hydrogels were prepared through the scientific cooperation program between Prof. Dr. El-Hady O.A. of the National Research Center, Cairo, Egypt and Dr. Pieh, S., of the Research and Development Dept., Chem., Linz GESMBH, Linz, Austria. (Pieh and El-Hady, 1990).

2. Experimental:

A completely randomized green house experiment with four replications for each treatment was conducted to study the effect of conditioning sandy soil with either organic manure or / and acrylamide hydrogels, i.e., nonionic (G1), Anionic (G2), cationic (G3) and mixture of G2 and G3 at the ratio of 2:3 (G4) on growth response, nutrients uptake and both water and fertilizers use efficiency by plants on one side and physico – biochemical properties of the soil on the other side. Ryegrass (Lolium multiflorum) was taken as the indicator plant.

The following 19 treatments were examined:

a- Untreated sandy soil of Rafah experimental farm of NRC.

b- Soils treated with organic manure (OM) at the rates of 2% and 4% (w/w).

c- Soils treated with the hydrogels G1, G2, G3 or G4 at the rates of 0.2 % (w/w)

d- Soils treated with mixtures of OM and hydrogels at the rates of 1% OM +0.1 % hydrogel, 2% OM + 0.1 % hydrogel and 2% OM + 0.2 % hydrogel.

Water was slowly added to reach pot by a drip system to allow complete hydration of the conditioners. After two days pot were planted with ryegrass seeds. Fertigation was carried out using 1g /l fertilizer solution (19:19:19).

After the 3rd cut of ryegrass i.e. after 150 days of plantation, the following chemical and biological properties of the soil were determined:

1- Soil pH, in 1:2.5 soil water suspension, Organic matter content, CEC, total organic and available N and total and available P and K were determined according to (Cottenie et al., 1982).
2- Surface area of the soil was estimated colorimetrically using orthophenanthroline adsorption method (Lowrie, 1961).
3- Total Bacteria, actinomycetes and fungi were determined using nutrients agar medium (Difco, 1966), glycerol nitrate agar medium (Szabo, 1974) and Maftins medium for fungi (Allen, 1953), respectively.

4- Dehydrogenase and phosphatase activity were determined after Skjins , (1973) for the 1st Enzyme and Khaziev, F.K.(1968), for the 2nd one.

Table (3) : Description of the main constituents and properties of the used acrylamide hydrogels used:

a-Main constituents	Nonionic	Anionic	Cationic
Active substance	Propeneamide Polymer	Propeneamide Propionic acid Co-polymer (K-Salt)	Propeneamide Allylamine Co-polymer (Cl-Salt)
Ionization degree	0	30 mole%	20 mole%
Cross linker	----------	Divalent vinyl monomer	
Crosslinking ratio	----------	1:10⁴ mole/mole	----------
Percentage of active Substance	----------	Greater than 88%	----------
Monomer content	----------	Not higher than 300 ppm	----------
b-Properties			
Appearance:	----------	white to slightly yellow grains	----------
Grain size :	----------	0.25 -1 mm	----------
Bulk density:	----------	≈ 600 kg/cm³	----------
Solubility	----------	Insoluble in water and organic solvents	----------
pH 0.1% in distilled H_2O	----------	7 ±0.5	----------
CEC C mole kg-1	2260	2045	2175
Absorption capacity In g/g hydrogel :			
De ionized water	≈ 300	≈ 525	≈ 430
0.9 % NaCl	≈ 33	≈44	≈ 35
0.4% $CaCl_2$	≈ 28	≈41	≈36
Saline water (1500 ppm)	≈ 42	≈ 64	≈54
Absorption time			
Up to 50 %:	----------	20 minutes	----------
Total absorption	----------	60 minutes	----------

RESULTS AND DISCUSSION

Some chemical and biological properties of Rafah sandy soil as influenced by conditioning with organic manure or / and hydrogels are presented in Table (4). Data reveal that all studied properties were improved by varying degrees due to soil conditioning as follows:

1- Soil pH:

All examined conditioning treatments slightly decreased the values of this soil property. This decrease was calculated to be 0.06 and 0.1 units by applying 2 and 4%, respectively. Using hydrogels as soil conditioners lowered soil pH by 0.27 - 0.4 units being lower when a mixture of the anionic and the cationic hydrogels was applied . By treating the soil with both conditioners together, the decrease in soil pH was calculated to be 0.28 -0.41 units, 0.17-0.23 units and 0.1 – 0.18 units with 1% OM + 0.1 G1; 2% OM +0.1% G and 2% OM+ 0.2G, respectively.

2- Cation Exchange Capacity and specific surface area:

One of the important limitations of soil fertility of sandy soils is its low CEC and subsequently its low specific surface area since many soil properties such as adsorption of water, nutrients and even gases and the attraction of particles for each other are all surface phenomenon.

Values of both properties in untreated Rafah sandy soil were 3.02 C mole kg^{-1} and 6.92 m^2/g , respectively. Treating the soil with organic manure raise both soil parameters being higher with the application rate of applied manure . While using 2% OM as a conditioner for sandy soil raised its CEC or specific surface area by 62.3 or 58.4 , in sequence , such increase due to doubling the application rate of OM to be 4% were 102.6 or 82.5 % , respectively . On the other hand, CEC or specific surface area of treated soil with 0.2 % hydrogels ranged between 2.2 and 2.4 times or 2.1 and 2.3 times that of the control treatment , for the nonionic and anionic hydrogels , respectively. By incorporating mixture of OM and hydrogels into sandy soil, the increase in both parameters in sequence ranged between 96.4 and 103.0 % and 88% 97.8% with 1% OM +0.1 G; 102.1 and 146.7 % and 111.1 % and 130.3 % with 2% OM + 0.1G and 176.5 and 185.1 % and 146.2 and 169.2 % with 2% OM + 0.2 G. It seems that CEC and surface area of treated soils coincide with the CEC of applied conditioners and their application rates.

Table (4) Effect of organic manure or / and acrylamide hydrogels on some bio-chemical properties of the tested sandy soil

No. of Treatment	Treatment: Conditioner used	Application rate (g/kg soil): OM	Application rate (g/kg soil): G	pH 1:2.5 H_2O	OM %	CEC Cmole Kg^{-1}	Specific Surface Area m^2/g	Available macronutrients N (mg/kg soil): NH_4	NO_3	NH_4+NO_3	P Mg/kg soil	K Mg/kg soil	Total N $\mu g g^{-1}$	Organic C $\mu g g^{-1}$	C:N	Activity of dehydrogenase*	Activity of phosphatase**	Total bacteria $X10^6/g$	Total Fungi $X10^4/g$	Total actino-Mycetes $X10^4/g$
1	Untreated	-	-	8.56	0.12	3.02	6.92	13.1	25.6	38.7	35.7	177.6	59.3	696	11.94	4.20	18.20	310	0.15	3.20
2	OM	20	-	8.50	0.49	4.90	10.96	17.4	51.3	68.7	55.3	453.2	564.3	2842	5.04	24.60	45.30	910	25.30	11.60
3		40	-	8.46	0.92	6.12	12.63	19.8	62.7	82.5	72.8	576.4	826.5	5336	6.46	40.60	64.50	1850	39.10	18.00
4	G1		2	8.29	0.54	6.73	14.53	15.3	50.4	65.7	56.7	281.4	424.3	3132	7.38	9.20	28.73	600	16.50	10.20
5	G2	-	2	8.25	0.51	7.32	15.81	18.6	55.5	74.1	58.8	416.8	458.9	2958	6.45	8.01	29.32	590	12.50	10.00
6	G3	-	2	8.21	0.53	7.00	15.12	15.6	60.6	76.2	62.5	331.0	419.8	3074	7.32	10.5	29.94	630	13.11	12.00
7	G4	-	2	8.16	0.56	7.15	15.45	17.2	59.3	76.5	60.9	377.5	491.5	3248	6.61	10.85	36.64	615	15.25	11.00
8	OM+G1	10	1	8.15	0.49	5.93	13.01	14.0	49.4	63.4	52.3	352.6	419.6	2842	6.77	23.50	46.90	850	25.00	11.30
9		20	1	8.36	0.69	6.66	14.61	16.1	52.7	68.8	69.8	561.2	511.2	4002	7.82	28.60	57.20	960	27.00	12.25
10		20	2	8.38	0.83	8.35	17.04	18.3	60.3	78.6	83.2	681.7	673.4	4814	7.14	34.40	63.12	975	32.50	13.10
11	OM+G2	10	1	8.28	0.49	6.13	13.69	15.1	51.4	66.5	56.7	448.7	394.5	2842	7.20	15.04	38.70	650	25.30	11.30
12		20	2	8.30	0.63	7.45	15.94	18.2	54.3	72.5	66.6	644.1	487.5	3712	7.61	26.60	60.40	1050	29.55	12.10
13		20	2	8.46	0.89	8.61	18.63	21.1	64.2	85.3	85.6	802.6	671.7	5162	7.08	31.60	62.76	1100	30.11	15.20
14	OM+G3	10	1	8.21	0.55	6.05	13.44	13.8	53.4	67.2	54.6	383.9	415.8	3190	7.67	30.07	50.42	1000	25.21	14.60
15		20	2	8.29	0.77	6.75	14.82	16.6	57.1	73.7	71.4	606.3	590.3	4466	7.57	35.24	58.62	1200	28.03	14.90
16		20	2	8.45	0.91	8.45	17.26	18.6	69.2	85.8	92.4	712.8	673.2	5278	7.84	30.30	67.12	1350	32.15	15.10
17	OM+G4	10	1	8.23	0.52	6.11	13.58	14.7	52.3	67.0	56.8	415.6	421.0	3016	7.16	24.40	45.43	925	26.15	12.25
18		20	2	8.33	0.85	6.93	14.98	16.9	56.3	72.2	81.1	620.4	479.8	3770	7.86	27.10	47.50	950	28.30	13.80
19		20	2	8.41	0.78	8.54	17.83	20.0	68.6	88.6	94.5	786.1	605.4	4524	7.47	35.50	59.80	1120	35.20	14.10

*m/H_2/g dry soil /24 h.

**mg/P_2O_5 /100 soil /24h.

3.Soil organic matter % and organic carbon content:

Treating the soil with organic manure raises both soil parameters being higher with the rate of applied manures. In other words, using 2% and 4% OM increased organic matter and organic carbon content of sandy soil to be 4.08 and 7.67 times that of untreated soil, respectively. On the other hand, organic matter and organic carbon content of treated soil with 0.2% hydrogels ranged between 4.25 and 4.67 times that of the control treatment. By adding mixture of OM and hydrogels to sandy soil, the increase in its organic matter and organic carbon content over that of the control treatment ranged between 308 and 358% with 1% OM + 0.1% G, 433 and 542 % with 2% OM -0.1% G and 550 and 658 % with 2% OM+ 0.2 % OM + 0.2 % G.

4. Total Nitrogen , Organic Nitrogen and C/N ratio:

Similarly , total nitrogen and organic nitrogen content take the same trend of organic matter % and organic carbon content . Compared with the control treatment, values of total N were highly increased to be 9.7 and 14.2 times with 2% and 4% OM, respectively , and 7.2 – 8.4 times with 0.2 % of the applied hydrogels . Relevant values for organic N were 25.3 and 38.0 times and 17.2 – 21.2 times , in sequence. Increases in total N due to applying mixtures of OM and hydrogels to sandy soil ranged between 577 and 622 % with 1% OM + 0.1 G, 723 and 913 % with 2% OM +0.1 % G and 938 and 1055% with 2% OM+ 0.2 % G . Furthermore , increases in organic nitrogen over that of untreated soil arranged in the same manner were 1573- 1717%, 1992-2536% and 2532-2935%, respectively.

Because the increase in organic carbon is far beyond that of total nitrogen , carbon nitrogen ratios are much more narrower . While C:N of untreated sandy soil was 11.94:1, it decreased to be 5.04:1 and 6.46:1 by treating the soil with 2% and 4% , organic manure, respectively. By treating the soil with examined hydrogels, values of C:N ranged between 6.61:1 with G4 and 7.32 :1 with G3 that means a decrease in this ratio equals to 38.7 – 44.6% . Using mixtures of organic manure and hydrogels decreased C:N to be 6.7:1-7.2:1, 7.57 : 1 – 7.86:1 and 7.14 :1 – 7.84 :1 with mixtures of 1% OM and 0.1 % G, 2% OM and 0.1% G and 2% OM and 0.2 % G, respectively . This means that the decrease in C:N ratios due to the aforementioned treatments were 39.7 – 43.9% , 34.2 – 36.6% and 34.2 - 40.2% , consequently. Such decrease in C:N refer to the easiness of the mineralization of organic nitrogen compounds, and the possibility to save and provide available forms of N to growing plants.

5. Available nitrogen, phosphorous and potassium:

Availability of nutrients in untreated sandy soil is low . Under the conditions of conducted experiment, and although fertilization is the same as that of other treatments , available N, P and K were 38.7, 35.7 and 177.6 mg/kg soil, respectively , that refer to poor nutritional status of the soil. Considerable increases in the availability of studied nutrients were noticed due to soil conditioning. Using 2% OM as a conditioner for sandy soil raised its nutrients availability by 77.5%, 54.9 % and 155.2 % for N, P and K , respectively . Doubling the application rate of OM to be 4% raised the availability of the three nutrients to be 213.2, 203.9 and 324.8% that of untreated soil, respectively . By applying hydrogels for soil conditioning , increases in the availability of the aforementioned nutrients ranged between 69.8 and 97.7 % for N, 58.8 and 75.1 % for P and 58.4 and 134.7% for K. Compared with untreated soil , the combined effect of both types of soil conditioners raised the availability of studied nutrients to be 1.64- 1.74 , 1.78 – 1.90 and 2.08 – 2.29 folds for N, 1.47 – 1.65 , 1.92 – 2.27 and 2.33 – 2.65 folds for P and 1.99 – 2.53 , 3.16 – 3.63 and 3.84 – 4.52 folds for K, using 1% OM + 0.1% g, 2% OM+ 0.1% g and 2% OM + 0.2 g, respectively.

It is worthy to note that the chemical composition of added hydrogel, i.e. , its ionicity has a specific effect on the available form of the studied nutrients . In other words, availability of nutrients in their cationic form, i.e. NH_4^+ or K^+ , could be arranged descendingly due to the use of hydrogels as follows:

anionic hydrogel > anionic + cationic hydrogels > cationic hydrogel > nonionic hydrogel.

While that for nutrients availability in their anionic one, i.e. NO_3^- or $H_2PO_4^-$ is as follows:

cationic hydrogel > anionic + cationic hydrogels > anionic hydrogel > nonionic hydrogel.

It seems that the effect of OM when mixed with hydrogels is additive. Availability of studied nutrients are much higher by applying the two types of soil conditioners together than that due to adding each of them alone . With only few exceptions , the aforementioned arrangements could be verified . Moreover, the effect of mixtures of anionic and cationic hydrogels with OM seems to be more clearer especially with P.

6. Total counts of bacteria , fungi and actinomycetes:

As, increasing the low number of micro- organisms (bacteria , fungi and actinomycetes) in sandy soil indicates an improvement in its biological

fertility, data presented in Table (4) refer to such improvement due to soil conditioning with OM or hydrogels their mixtures . While applying 2% OM to sandy soil increased the number of total bacteria, fungi and actinomycetes by 194 , 16767, 263% in sequence, such increase were 497 , 2567 and 463 % , respectively when the rate of OM was doubled to be 4% Regarding hydrogels , 0.2% of examined polymers increased the aforementioned numbers by 90 to 103% for bacteria,8233 to 12233% for fungi and 213 to 275 % for actinomycetes . By incorporating both conditioners into sandy soil , total bacteria were 210 to 323 % , 274 to 397 % and 315 to 435% that of untreated sandy soil using 1% OM + 0.1 % G, 2%OM + 0.1% G and 2% OM + 0.2 %G, respectively . Relevant values for actinomysetes were 353 to 456, 378 to 466 and 409 to 475% , in sequence

7. dehydrogenase and phosphatase activities:

Since most of the biological reactions in the soil are enzymatic changes, enzymes activity could be considered as another parameters to characterize the biological activity of the soil. With this respect both dehydrogenase and phosphatase activities were essayed . Data indicate the increase in the activity of both enzymes by soil conditioning . Regarding OM , applying 2% of this conditioner to sandy soil , raised the biological activity of soil enzymes by 486% for dehydrogenase and 149% for phosphatase . More increase in enzymes activity was obtained when higher rate of OM (4%) was added to be 967% and 349 % relative to that of untreated soil for both enzymes, respectively. Conditioning sandy soil with hydrogels increased also enzymes activity in the soil but with lower degree . Increase in enzymes activity due to applying 0.2% hydrogels ranged between 90.7 and 158.1 % and 58 and 101 % for dehydrogenase and phosphatase activities, in sequence being higher with G4, i.e., mixture of the anionic and the cationic hydrogel. Using both conditioners, together, activity of dehydrogenase reached 716, 839 and 936 % that of untreated sandy soil by applying 1% OM + 0.1 % G, 2% OM + 0.1 G and 2% OM + 0.2 % G, respectively. The same could be noticed for phosphatase . Increase in its activity reached 1.77 , 232 and 269 % that of untreated soil for the three aforementioned soil treatments , respectively.

Obtained results could be discussed on the basis of the combined and interacted effects of both OM and hydrogels on hydrophysical ,part one of this research work (El-Hady et.al ., 1995a and b and Abd el Hameid, et al., 1995) chemical and biological properties of sandy soil and in trun on plant growth, nutrients uptake and both water and fertilizer use efficiency by

growing plants (El-Sherbeiny et al., 1995 ; El-Hady et.al., 2000 b and c and Arafat and El-Hady, 2000), where a conclusion drawn that mixing both types of soil conditioners together is more efficient on improving soil properties that applying each of them alone . Application rate of mixture's components and the ionicity of applied hydrogel are considered of important factors that highly affect soil conditioning . Results clarify the high efficiency of using mixtures of anionic and cationic hydrogels particularly when combined with OM.

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الملخص العربى

مركبات الهيدروجل لزيادة الاثر التحسينى للاسمدة العضوية

٢.اثرها على بعض الخواص الكيميائية و البيولوجية للتربة.

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اقيمت تجربة فى الصوبة فى نظام تام العشوائية ذو اربعة مكررات اتخذ فيها الراى جراس كنبات دليلى وتم فيها الرى و التسميد معا بنظام الرى الغذائى fertigation بمحلول سمادى تركيزه ١جم فى اللتر من السماد المركب ١٩:١٩:١٩ اختيرت فى هذة التجربة المعاملات التالية :

أ- تربة رفح الرملية (بسيناء) الغير معاملة (معاملة الكنترول)

ب- التربة المعاملة بالسماد العضوى بمعدل اضافة ٢% و ٤%

ج- التربة المعاملة بمركبات البولى اكريلاميد هيدروجل الغير ايونى G1 و الانيونى G2 و الكاتيونى G3 و مخلوط الانيونى و الكاتيونى بنسبة ٣:٢ G4 بمعدل اضافة ٠,٢ لاى منها.

د- التربة المعاملة بمخلوط السماد العضوى و اى من مركبات الهيدروجل سالفة الذكر بمعدل اضافة ١% سماد عضوى+ ٠,١% هيدروجل او ٢% سماد عضوى+ ٠,١% هيدروجل او ٢% سماد عضوى+٠,٢ هيدروجل.

ولتقيم الاثر المحسن لاى من السماد العضوى او مركبات الهيدروجل او مخاليطها على خواصى التربة فقد تم تقدير بعض الخواص الكيميائية و البيولوجية فى التربة بعد الانتهاء من الحشة الثالثة للراى جراس اى بعد ١٥٠ يوما من الزراعة.

ادت اضافة المحسنات الى خفض رقم الpH التربة وزيادة كل من السعة التبادلية للتربة بالكاتيونات و السطح النوعى لها مؤكدة التحسن فى نشاط التفاعلات الكيميائية بها كما تحققت زيادات فى كل من النسبة المئوية للمادة العضوية و مكون الكربون العضوى و النتروجين الكلى والعضوى فى التربة . و لان الزيادة فى النترروجين الكل كانت اعلى منها فى الكربون العضوى فقد ضاقت النسبة بين الكربون : النتروجين مؤكدة سهولة معدنة مركبات النتروجين العضوية و بالتالى امكانية الامداد بصور النتروجين فى صورة صالحة للنباتات النامية هذا بالاضافة الى ان قابلية كل من عناصر النتروجين و الفوسفور و البوتاسيوم للاستفادة بالنبات قد زادت بدرجة ملحوظة . كما ان النتائج تشير الى ان النشاط البيولوجى للتربة مقيسا بالاعداد الكلية للبكتيريا و الفطريات و الاكتينوميسيتس / جم تربة و النشاط الانزيمى لكل من الدهيدروجينيز و الفوسفاتيز قد تحسن بدرجة كبيرة باضافة المحسنات للتربة الرملية . خلط كلا النوعين من المحسنات (اى المادة العضوية و مركبات الهيدروجل) معا كان اكثر كفائة فى تاثيرة المحسن لخواص التربة عن اضافة اى منها بمفردة. و يعتبر كل من معدل اضافة مكونات الخليط و ايونية مركبات الهيدروجل المستخدمة من العوامل الهامة التى تؤثر تاثيرا كبيرا فى عملية

Conclusions and Recommendation of the Symposium

Land degradation problems in Egypt and Africa differ from one place to another and from one country to another . They include the following: 1) water logging , salinity and alkalinity, 2) deterioration of soil fertility , 3) encroachment of desert in the fringes of the Nile Valley and Delta ,4) soil erosion ,5) soil pollution , and 6) non agricultural use of the land .total losses due to land degradation in Egypt in the order of the production were estimated as 2.35 million feddans :600 000 f. losses due to water logging ,salinity and alkalinity ,500 000 f due to the deterioration of soil fertility , 350 000 f as affected by desert encroachment and 800 000 f. are lost as non agricultural use of the land.

The following recommendation have been given by the symposium:

1. Land degradation problems require coordination of the various programs and cooperation of the various concerned authorities to face the problem in a national approach .
2. Establishment of a national data bank for African soils in the Institute of African Research and Studies and present the technical support to African countries to face the problems of land degradation.
3. All forms of land degradation should be assessed and evaluated by continuous monitoring of the process and evaluating of their effects. This assessment and evaluation lead to proper management and beneficial use for land and water resources for the future generations .
4. The problems of land degradation must be distributed regionally on the research centers and universities to follow up the problems and find solutions
5. Actual and potential land degradation should be mapped to interpretate the environmental factors that influence the extent and intensity of each form of land degradation.
6. The symposium proposed a creation of a high level authority responsible for planning and coordinating and follow up the implementation of the plans and programs for land conservation. This authority assess and evaluates the problems , draws up the proposed soil degradation map of Egypt , identifies the rate at which the problems occur , deals with the various aspects of land degradation and to be the central bank of information about the problems of land degradation .

7. Integrating the relationship between land user , research centers and decision makers to identify the forms of land degradation in a certain area and control them through proper technology and policy for agricultural sustainable development .

8. The symposium emphasizes that the old productive lands of Egypt (Nile alluvial valley and delta) should be conserved where the reclamation of the new lands is a process of high cost .

9. Extension service should be highly supported and the extension workers should be provided by specialized training and experience in conservation practices. Education to the public is also important to appreciate land and soil conversation.

10. When planning large scale projects for land reclamation such as Tushka project all agricultural inputs should be taken into consideration and managed taking care of the adverse -side effects.

11. In the field of soil pollution ,the symposium assure the following proposition :

   - Evaluate the residual effects of different fertilizer and pesticides in a national plan to define their environmental impacts ,
   - Study the sorption / desorption kinetics of pesticides to understand their behaviour in different soils ,
   - The continuous environmental monitoring of drain water to assess their contents of pollutants and put criteria to its agricultural use ,
   - Great care has to be given when selecting the pesticides to be used and
   - pest biological control should be given higher priority to reduce the use of pesticides .

12. A green belt should be planted on the fringes of the Nile Valley and Delta to protect their fertile alluvial soils from desert encroachment. Low quality water and sewage water should be used in planting this belt instead of draining it to the Nile.

13. Wind erosion is a serious problem in Egypt . attention should be given to this problem because it threatens agricultural lands , roads , and constructions. Information exchange should be made between research centers to evaluate this serious problem and use different measures to conserve the land .

14. Attention and support should be given to all present efforts in establishing accurate and efficient drainage networks especially in

the north of the delta and in Siva oasis that expose to severe degradation due to high salinity andground water levels.

15. lands not suitable for agricultue provided with all required infrastructure should be made available for construction in order to encourage people to stop building on agricultural land and the government should stop doing so first

16. land degradation problem, as the case with all environmental problems, is multidimentional. So , te solution cannot be of one dimention . It requires contributions from different fields , i.e., natural sciences , technology in the usc of resources , economics , and sociology . Land is considered the result of the physical environment which includes climate relief , parent rock and vegetation that influence the potential o land use . It also includes the result of past and present human activity.

17. Soil conservation requires enough investments . High priority should be given to these investments or two reasons : a) the investments required for conserving the land against degradation will be far less than those required for recaiming the degraded one taking into account the socio-economic osses during the period between the start of the land degradatio and the completion of reclamation process , b) the investment in the field of land conservation are highly feasible and will py back in a short time. Industry can contribute to the costs of soil onversation by peering the costs of treatment or re-cycling of the wastes and pollutants resulted from different industries . Part of he land tax could be used for conservation purposes . A tax on irgation water could be feasible too because part of land degradation esults from over --use of irrigation water. High taxes should be harged for any non-agricultural use of the land .

18. Participants announced their protests against te inhuman behavior that Israel practices against the Palestinian erritories and the destruction of their farms . It is considered a sεious form of land degradation .

19. In the field of soil biology , the symposium recommends the following .

- Great attention should be given to bio-organic fertilizers especially in the new lands .
- Use of untraditional and save sources to produce organic materials such as farm residues , food industries residues , and garbage free from pollutants .
- Use of synthetic soil conditioners such as hydrogel to increase the efficiency of organic fertilizers.
- Encourage the role of soil fauna in improving physical, chemical and biological soil characteristics .
- More studies should be made about the above mentioned items .

20. The participants of the symposium hope that the national planners and decision makers will have a long term view in dealing with land use planning and will give the recommendations of this symposium full consideration.

رقم الإيـــداع
٢٠٠٣/١٦٩٧٦